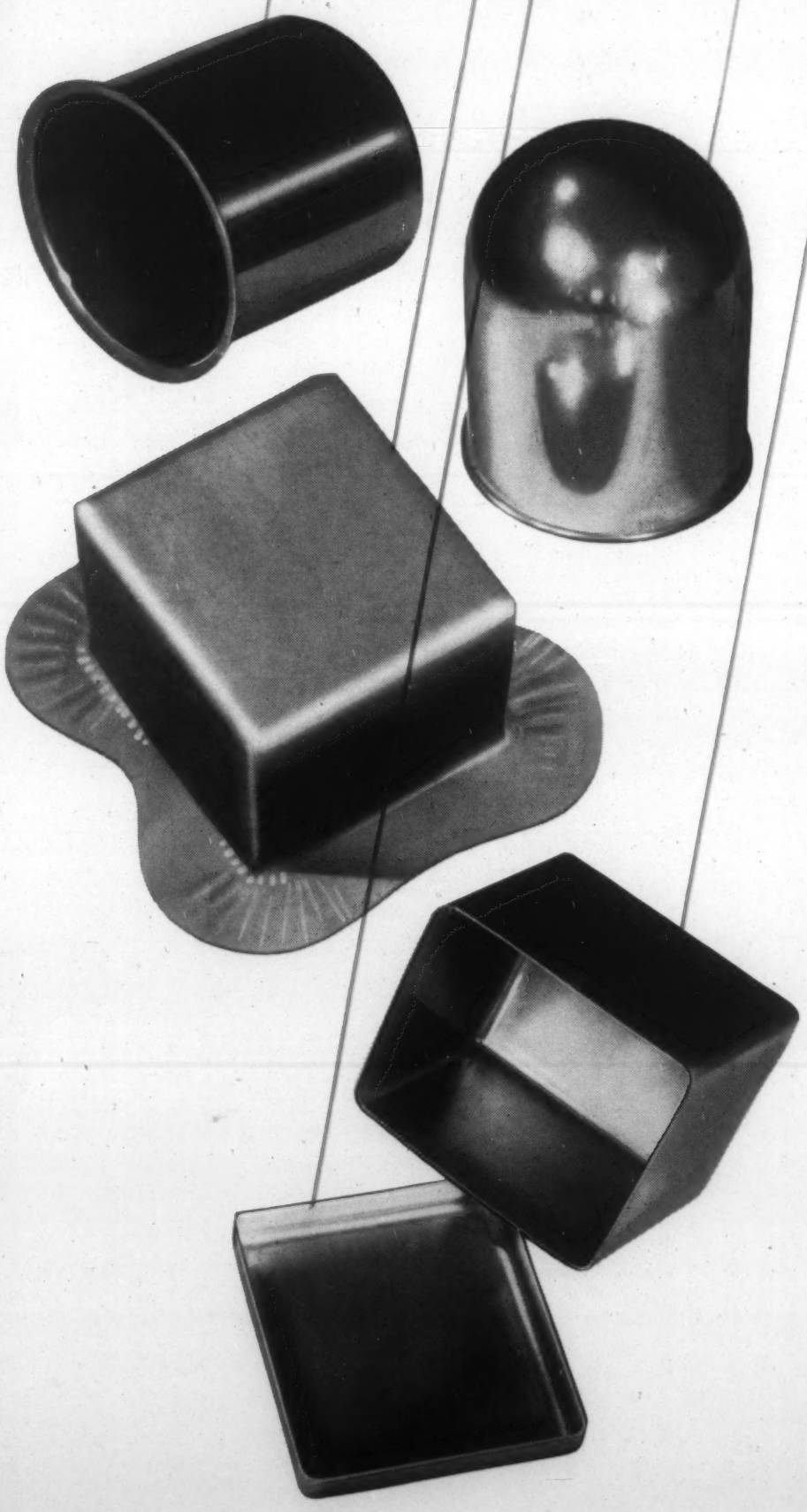
Metals and Alloys

THE MAGAZINE OF METALLURGICAL ENGINEERING

PRODUCTION · FABRICATION · TREATMENT · APPLICATION

MARCH 1941

DOWMETAL MAGNESIUM



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Metals and Alloys

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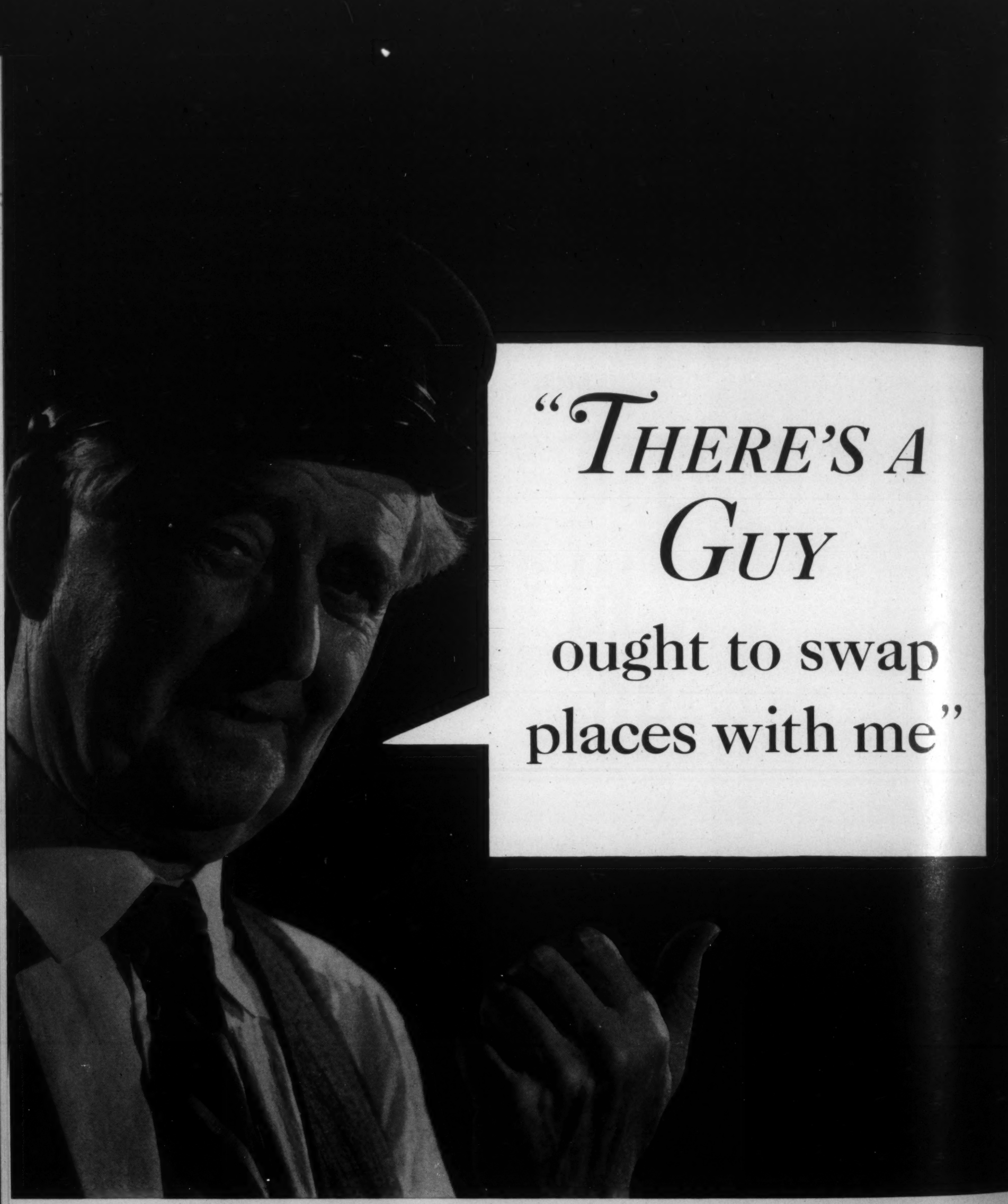

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Feature Section

Low Alloy Steels

In October, 1938, we published a rather complete survey of all the then known low-alloy, high strength steels. In this issue we bring this survey up to date, showing the changes in composition and physical properties of the various steels, alterations in names, and any new steels placed on the market. Accompanying the article are pictures of recent applications of some of these steels.

Heat Treating Rivet Studs

This practical heat-treating article describes the use of a resistance heater of the Berwick type for softening the tenons of certain case-hardened rivet studs. The use of an induction heater for the selective hardening of the heads and bodies of others is included.

Metallography of Stainless Steels

The third instalment of Mr. Watkins' article on the practical metallography of the stainless steels is presented. Again the illustrations are a feature. The concluding section will be published in April.

Al and Zr for Precipitation Hardening

Further information on the general subject of precipitation hardening is offered by Mr. Nippes. There is keen interest in this phenomenon which was discovered only a few years ago. The author finds that, for hardening certain alloys of copper and nickel, both aluminum and zirconium are very effective and they discuss the melting procedure, the heat treatment and so on of alloys to which aluminum and nickel have been added to take advantage of their precipitation hardening effect.

Electric Heat-Treating Plant

One of the finest and largest electric heat-treating plants in the country is the one at the Bethlehem Plant of the Bethlehem Steel Co. Some recent additions to the equipment of this unit are described in our News Section.

Ingot Molds

Metallurgical engineers responsible for ingot quality and their foundry confrères who produce the molds will find many data on mold life—the subject of much polite argument between them—in a composite on page 331 which also gives information on steel quality as affected by mold geometry and composition.

Engineering Digests

Shell Forging

Even though it's trite to call attention to the present-day importance of shell-forging methods, we can't help highlighting a composite on this subject on page 338, which gives brief descriptions and some respective advantages of the 3 most important processes—piercing and drawing on 2 hydraulic presses, displacement-piercing on a mechanical upsetting forging machine; and piercing and drawing in a single mechanical unit.

Magnetic Heat Treatment for Magnets

Appropriately enough, a new heat treatment for magnets, developed in Germany, involves the application of a strong magnetic field to the work during cooling. The treatment gives iron-nickel-cobalt-aluminum-copper alloys an even higher BxH_{max} value than ordinarily, reports Jellinghaus (page 342).

Salt Bath Practice for Aluminum Alloys

Several practical hints for engineers concerned with salt-bath heat treatment of aluminum alloy parts are offered by Finch (page 349).

Nickel Beer

The nickel subway fare in New York arrived years ago, but the country still seeks a good nickel cigar and, we are reminded by an article by Mason (page 360), a good nickel glass of beer. Mason finds nickel-base alloys very good for brewery equipment, thus providing a refreshingly new approach to the problem of getting the beer and the nickel together.

Defining Defects

Standards for quality of heavy-wall carbon-moly pipe have been made more specific by subcommittee 22 of A.S.T.M. Committee A-1, reports Crocker (page 369), so that testing engineers won't be required in the future to dream-up judgments on "moderate" or "immoderate" slivers.

But the Job's in Production Now!

TESTED by twisting—four times 'round, this butt-weld of copper to aluminum proved that these two metals *could* be joined together in a satisfactory manner—with today's improved resistance welding doing the job. The finished weld showed a perfect bond even under a magnification of 250 times!

Because of improvements made in modern resistance-welding machines and modern controls, especially electronic control, resistance welding is fast making yesterday's impossibilities a part of today's regular production.

If you now use, or can use, resistance welding, you'll be assured of maximum production speed—which means profit, too—if you equip your welders with G-E electronic controls, contactors, circuit breakers, and cable. General Electric equipment is readily applied to existing installations or to new-machine installations. In *every* case, it will pay you to specify G-E equipment.

Full details from your G-E office, or write General Electric, Schenectady, New York.

In EVERY case, it will pay you to specify G-E equipment.

GENERAL ELECTRIC

"Rare and Minor Metals"

We got a kick out of *Daily Metal Trade* for Feb. 3, where are listed the prices for arsenic (as *white* arsenic which is not a metal), beryllium as beryllium-copper, bismuth, cadmium, cobalt, iridium, magnesium, palladium, platinum, mercury and selenium. Neither elemental arsenic nor selenium is unmistakably a metal, but that doesn't particularly matter; the amusing thing is that magnesium is still called a "minor" metal. On the same page is a statement that the 1941 Dow production of magnesium will be 30,000,000 lbs. When the number of digits rises to New Deal proportions, it's about time to talk in tons and call it 15,000 tons. Anyhow, it's about time to recognize that magnesium has reached voting age, quit calling it a minor, and move it over to the non-ferrous page that carries quotations on silver, gold, aluminum, copper, nickel, lead, tin and zinc.

Another page of this same issue remarks that the price of iridium has just been dropped from $275 to $175 per ounce on the say-so of Leon Henderson that its price was too high. Anything that can have its price thus affected or anything normally priced per Troy ounce, is reasonably classed among minor metals, by which argument gold would go in that category. It would, however, be a psychological help to the effort to find commercial uses for silver if the price of foreign-produced silver for industrial use were recorded as $5.10 per avoirdupois pound—instead of quoting in Troy ounce. People accept, as nothing unusual, the commercial use of beryllium, despite the fact that it costs three times as much as silver, and, at that, in the form of an alloy, not the pure metal.

Columbium, titanium, zirconium and phosphorus, as ferros, are quoted among ferroalloys, and have such important uses that it is not felt necessary to degrade them by calling them "minor." Yet cobalt, a "minor" metal, is, in high speed steel, in sintered carbide tools and dies, and in magnets, as useful or indispensable as these. Indeed, it's a darned sight harder to find a substitute for, than any one of these four.

Our own advertising pages record not only (p. 96 January issue) that bismuth is commercially useful in die-setting, tube-bending, and like alloys, but that indium (page 92, January) and osmium (page 100, January) are also in the commercial picture.

Tellurium bids fair to find important metallurgical use that should soon justify carrying its current quotation along with selenium.

We can remember when molybdenum was listed among the "rare and minor" metals. All of which goes to show that there's a use for everything if we can find it and very probably also a supply, if we can find it. The one metallic or near-metallic element that certainly isn't rare, but for which no very important use has yet cropped up, is elemental arsenic.—H. W. G.

Priorities, Plastics and "the Peace"

If politics make strange bedfellows, those produced by the defense program are curiouser and curiouser. No one in his right mind two years ago would have predicted that in 1941 METALS AND ALLOYS would editorially bless a program to substitute plastics for metals in product design—but then not even Jim Farley could have successfully predicted much of what is happening today.

The plain truth is that munitions are currently taking such toll of the supply of certain metals—aluminum, magnesium, zinc and stainless steel particularly—that "non-defense" manufacturers using them as the design-bases for certain products are facing a serious procurement problem of their own. At the same time, and just to make it official, the OPM has (1) urged magnesium producers to consign their stocks to national-defense products where possible, (2) requested non-defense manufacturers to explore the feasibility of redesigning their aluminum products for other materials, such as plastics, and then, more recently actually applied priorities to the output of the metal, and (3) hinted that priorities may yet be applied to guarantee employment of the mounting zinc production in armament applications, particularly brass for shell casings.

The desirability of relieving the vital pressure of defense-metal needs by using non-metals wherever possible for "peace-time" products is powerfully evident. Simple patriotism impels the following of such a course by everyone in a position to influence decisions as to metal application. But crass commercial self-interest just as strongly suggests it—and to both the users and producers of these particularly hard-pressed metals.

To users, replacement of certain metal-forms by plastics may seem at first to offer little in the way of profit. Metallurgical engineering designers have specified zinc, aluminum or magnesium alloy die castings, permanent-mold castings, sand castings, forgings, extrusions or screw-machine parts, or light-gage stainless steel stampings, where considerations

(*Continued on page 301*)

How to get Steel *More Quickly*

A practical suggestion that may help you

SPEED your steel by sending open orders (not inquiries) to a dependable source of supply. We are glad to receive all inquiries and give them prompt personal attention but with today's emergency demands there is a chance that certain stocks may become depleted while the request for quotation is being handled.

Here at Ryerson, stocks are remarkably complete, deliveries are prompt. Out-of-the-ordinary demands may, however, temporarily deplete our stock of a particular size. Because of recent experiences our advice is this: If you need steel, order it! Don't wait for quotations. An open order to Ryerson will get you the same price, and, will be shipped at once.

Have no hesitancy in placing an open order, for Ryerson stands on its 99 year reputation as a reliable, one-price house. You will save valuable time, and more important, you will have the steel you need when you need it. Joseph T. Ryerson & Son, Inc. Steel-Service Plants at: Chicago, Milwaukee, St. Louis, Cincinnati, Detroit, Cleveland, Buffalo, Boston, Philadelphia, Jersey City.

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THE PRESENT STATUS OF THE

Low-Alloy, High Strength Steels

—A Survey

by EDWIN F. CONE

THE GROUP OF STEELS, familiarly known as the low-alloy, high strength steels, has been on the market for a number of years now and many of them have been undergoing the real test of service and experience. In October, 1938, we reviewed the status of all of the then-known brands, giving the composition, physical properties, and the applications of some of them.

We again review the field, to record changes in the specifications, the experience which some companies have had with these steels, and the introduction of new brands.

To obtain a complete picture of the various steps in the development of this type of steels—a history which cannot be repeated here—it will be necessary for the reader to consult the various articles and papers which have been published—a list of them is appended to this article.

The steels were primarily developed to lighten the dead load, without sacrifice of strength, of transportation equipment. Corrosion is sometimes a factor also. Due to the thinner section of the steel as used, it is desired to increase the corrosion resistance by a corresponding amount, though in many cases where the steel can be kept well painted this is not a necessary requirement. Considerable attention has been given to improving the anti-corrosion properties of the steels, as well as to maintain or increase their physical properties. Changes in the analyses of some of the steels reflect this trend.

There has been a suggestion regarding the name of this class of steels, the present one—low-alloy, high strength—being cumbersome. An editorial in the November, 1940, issue of METALS AND ALLOYS, page 613, suggested that these steels be designated as "Mild Alloy." Possibly gradual usage of this name may result.

The present status of all these steels, old and new, is discussed in this presentation based on replies to a questionnaire sent to the producers and sponsors of the different steels. A few illustrations of recent applications of some of them are included. In the tables, present chemical and physical properties of each steel are assembled. As in the last review the "early or non-proprietary steels" are shown first, followed by the "steel company steels" including new brands.

The Early Steels

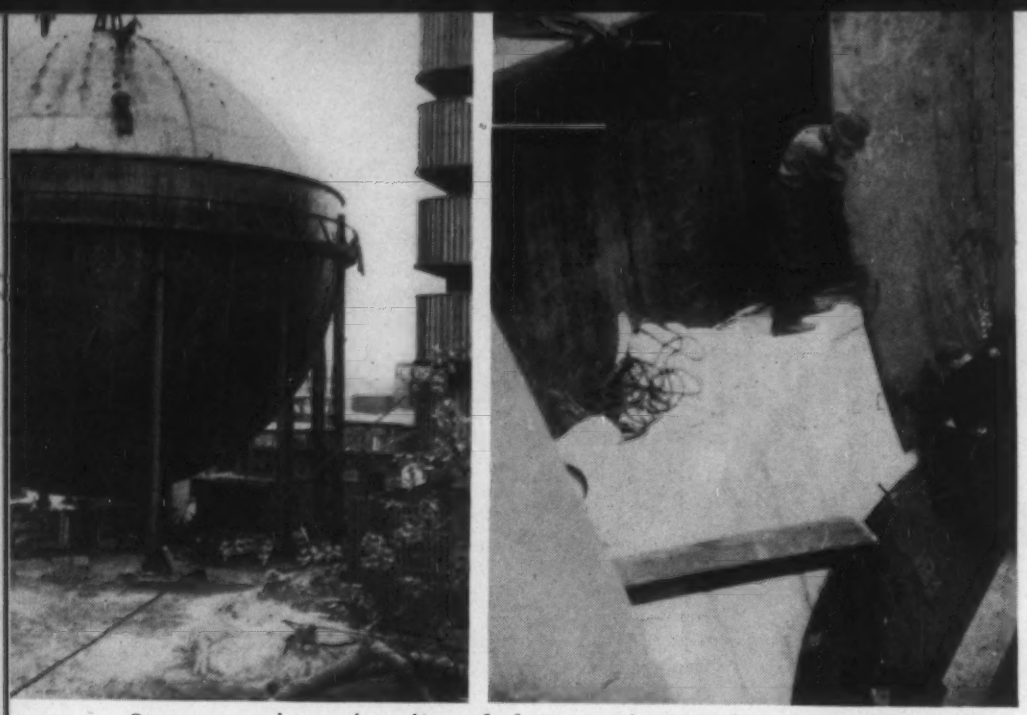
THE GROUP OF low-alloy high strength steels which have been in existence for some time, several of them many years, are still important. This group is contrasted with the so-called "company steels" and are generally regarded as the non-proprietary steels. They include the S.A.E. nickel, nickel-chromium, and nickel-molybdenum steels, the medium manganese, silicon structural, chromium-vanadium, Cromansil, manganese-vanadium, carbon-molybdenum, and manganese-molybdenum steels. The present status of this group is discussed in the following paragraphs.

The Nickel Steels—International Nickel Co.

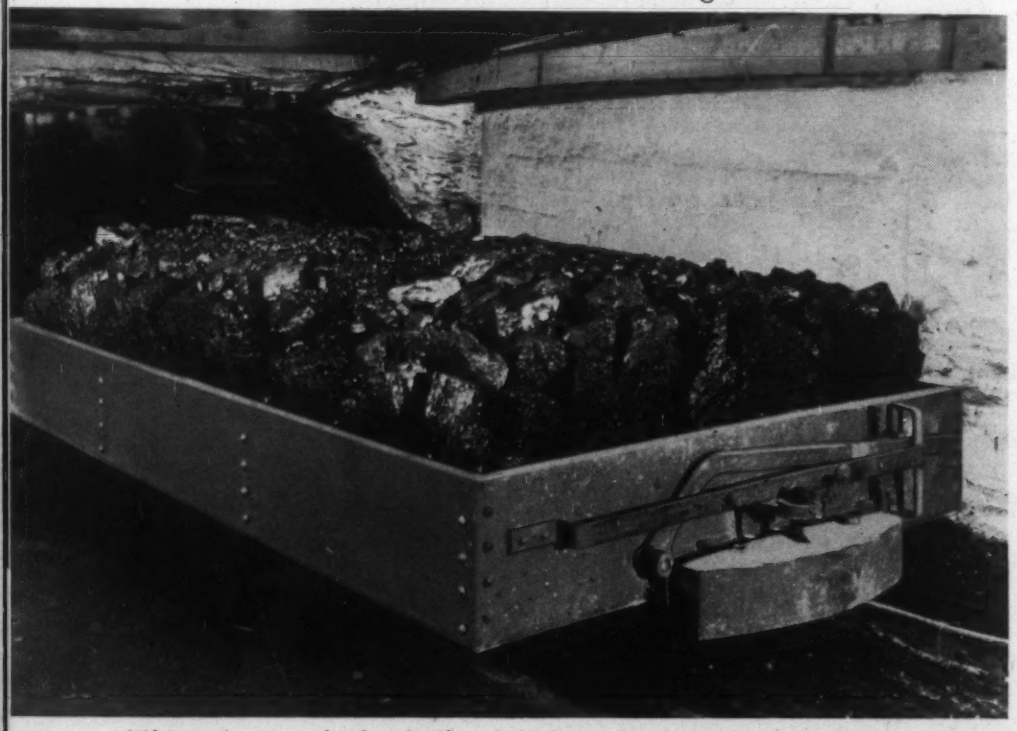
Since the review of 1938, steady progress has been made in the effective utilization of the non-proprietary nickel alloy constructional steels, including S.A.E. grades, in the rolled, normalized or annealed conditions. Individual types are being used in the form of plates and shapes, as in the past.

The 2 per cent nickel steels are being specified for locomotive boilers; the 3½ per cent nickel steels for highly stressed members in bridge construction, and the nickel-chromium and other nickel alloy steels are being used in mining and excavating equipment and similar applications.

The major change in the situation is probably the more widespread use of low carbon nickel steels

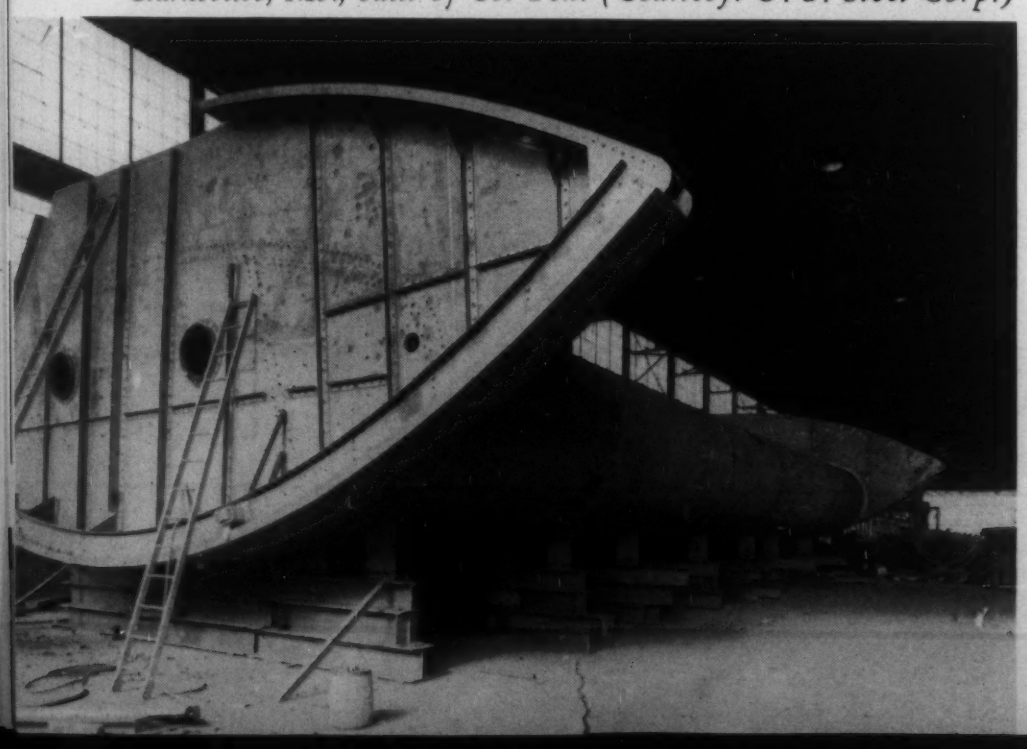


Storage sphere for liquefied natural gas during construction. The inner sphere is made of 3.50 per cent nickel steel, 57 ft. in dia. This is insulated with 3 ft. of cork. The outer sphere is of plain carbon steel, both spheres welded. At the left the inner sphere is shown completed. The other view is of a section showing the insulation. There are three of them located at the plant in Cleveland of the East Ohio Gas Co. Temperature involved is minus 265 deg. F.



This mine car body, built of U.S.S. Cor-Ten, is approximately 25 per cent lighter and carries 26 per cent more pay load than similar cars built of standard structural steel. (Courtesy: U. S. Steel Corp.)

A Tainter gate for Dam No. 24 in the Mississippi River at Clarksville, Mo., built of Cor-Ten. (Courtesy: U. S. Steel Corp.)



with from 2 to 3½ per cent of nickel, in the manufacture of welded pressure vessels and auxiliary equipment for service at sub-atmospheric temperatures. A recent installation of this sort was built for operating temperatures as low as —265 deg. F. Properties of the nickel steels are given in the tables.

"Cromansil"—Electro Metallurgical Co., New York

"Cromansil"—a Cr-Mn-Si low alloy steel—was developed some 8 or 9 yrs. ago by the Electro Metallurgical Co. of New York. It was in fact one of the first of the modern steels of this class. It is, however, no longer sponsored by a steel company. From the original sponsor the following facts have been received:

Commercially there are no longer two grades of this steel, A and B, as in 1938—there is now only one grade. Its composition is:

Carbon	—	0.14 max.
Manganese	—	1.10 to 1.40
Silicon	—	0.60 to 0.90
Phosphorus	—	0.055 max.
Sulphur	—	0.055 max.
Chromium	—	0.40 to 0.60

Yield point	—50,000 lbs. per sq. in. min.
Tensile strength	—80,000 lbs. per sq. in. max.
Elong. in 8 in.	—18.0 per cent

These new properties are more nearly like the former Grade B except that the carbon is lower.

There has, however, been a development which might be worth mentioning. The U. S. Navy Department specifications for high strength structural steels call for a minimum yield point of 50,000 lbs. per sq. in. and a maximum ultimate tensile strength of 80,000 lbs. per sq. in. with an elongation of 18 per cent in 8 in. The Navy also requires that the steel have certain welding characteristics which, while not unduly severe, are not always easy to meet. For a Cromansil steel to meet this specification, the composition given above is recommended. The actual properties obtained on two commercial heats falling within this composition, rolled into ½-in. plates, are as follows:

		No. 1	No. 2
Carbon	—	0.14	0.13
Chromium	—	0.47	0.36
Manganese	—	1.24	1.10
Silicon	—	0.76	0.75
Phosphorus	—	0.010	0.018
Sulphur	—	0.018	0.022
Thickness, in.		½	½
Yield point, lbs. per sq. in.		58,200	54,800
Tensile strength, lbs. per sq. in.		83,000	79,200
Elong. in 8 in., per cent		24.0	20.0

Manganese-Vanadium—Vanadium Corp. of America

In 1938 manganese-vanadium steel plate was specified in three grades with a carbon range of 0.18

Table 1—Composition of Present Day Low Alloy Steels (Per Cent)

	C	Mn	Si	Cu	Ni	Mo	P [2]	Other Elements
Early Steels:								
SAE 2115	0.10 to 0.20	0.30 to 0.60	.....	.....	1.25 to 1.75	.....	.....	.....
2 to 2.5% Ni	0.20 max.	0.40 to 0.80	.....	.....	2.00 min.	.....	.....	.....
2 to 2.5% Ni	0.35 max.	1.00 max.	.....	.....	2.00 min.	.....	.....	.....
SAE 2300	0.45 max.	0.85 max.	.....	.....	3.00 to 4.00	.....	.....	(ASTM—A8-36T)
SAE 3130	0.25 to 0.35	0.50 to 0.80	.....	.....	1.00 to 1.50	.....	.....	0.45 to 0.75 Cr
SAE 3115	0.10 to 0.20	0.30 to 0.60	.....	.....	1.00 to 1.50	.....	.....	0.45 to 0.75 Cr
SAE 4630	0.25 to 0.35	0.50 to 0.80	.....	.....	1.65 to 2.00	0.20 to 0.30	.....	.....
SAE 4615	0.10 to 0.20	0.40 to 0.70	.....	.....	1.65 to 2.00	0.20 to 0.30	.....	.....
Medium Mn	0.20 to 0.25	1.00 to 1.75	.....	.....	.....	.....	.....	.....
Si Structural	0.30 to 0.40	0.70 to 0.90	0.20 to 0.30	.....	.....	.....	.....	.....
Cromansil	0.14 max.	1.10 to 1.40	0.60 to 0.90	.....	.....	.....	.....	0.40 to 0.60 Cr
Mn-V	0.13 to 0.18	1.20 to 1.45	0.15 to 0.30	.....	.....	.....	.....	0.30 to 0.60 Cr
Cr-V	0.15 to 0.25	0.50 to 0.80	.....	.....	.....	.....	.....	0.08 to 0.12 V
C-Mo	0.13 to 0.25	0.50 to 0.90	0.15 to 0.30	.....	.....	0.40 to 0.60	.....	.....
Mn-Mo	0.15 to 0.30	1.20 to 1.75	0.20 to 0.50	.....	.....	0.20 to 0.50	.....	.....
SAE X4130	0.25 to 0.32	0.40 to 0.60	0.15 to 0.30	.....	.....	0.15 to 0.25	.....	0.80 to 1.10 Cr
Company Steels:								
Cor-Ten	0.12 max.	0.10 to 0.50	0.25 to 1.00	0.30 to 0.50	.....	.....	0.07 to 0.20	{0.50 to 1.50 Cr 0.55 Ni max.
Man-Ten	0.30 max.	1.10 to 1.60	0.30 max.	0.20 min.	.....	.....	0.04 max.[1]	.....
Yoloy	0.05 to 0.35	0.30 to 1.00	0.003 to 0.20	0.85 to 1.10	1.50 to 2.00	.....	.....	.....
RDS 1	0.12 max.	0.50 to 1.00	.....	0.50 to 1.50	0.50 to 1.25	0.10 min.	0.04 max.[1]	.....
RDS 1A	0.30 max.	0.50 to 1.00	.....	0.50 to 1.50	0.50 to 1.25	0.10 min.	0.04 max.[1]	.....
Hi-Steel	0.12 max.	0.50 to 0.70	0.30 max.	0.90 to 1.25	0.45 to 0.65	None added	0.10 to 0.15 [3]	Mo, V—none added
Armco High Tensile	0.12 max.	0.20 min.	0.10 max.	0.35 min.	0.50 min.	0.05 min.	0.05 to 0.15	.....
Jal-Ten	0.35 max.	1.25 to 1.75	0.30 max.	0.40 max.	.....	.....	0.04 [3]	.....
Konik	.....	.....	.....	0.10 to 0.30	0.30 to 0.50	.....	.....	0.07 to 0.30 Cr
Granite City HS1	0.14	0.70 to 0.90	0.15 to 0.20	0.25 to 0.30	.....	.....	.....	0.12 Cr
Mayari R	0.12 max.	0.50 to 1.00	0.05 to 0.50	0.50 to 0.70	0.25 to 0.75	.....	0.08 to 0.12 [2]	0.20 to 1.00 Cr
A.W. Dyn-El	0.11 to 0.14	0.50 to 0.80	.....	0.30 to 0.50	.....	.....	0.06 to 0.10	.....
N-A-X High Tensile	0.10 to 0.18	0.60 to 0.75	0.65 to 0.90	0.25 max.	0.10 to 0.25	0.15 max.	0.04 max.[1]	{0.10 to 0.15 Zr 0.50 to 0.65 Cr
Lukens Steels:								
Ni Steel	0.25 max.	0.80 max.	0.15 to 0.30	.....	2.00 to 2.75	.....	0.035 max.[1]	.....
C-Mo	0.28 max.	0.50 to 0.90	0.15 to 0.30	.....	.....	0.40 to 0.60	0.035 max.[1]	.....
Cr-Mn	0.35 to 0.45	0.80 to 1.00	0.15 to 0.40	.....	.....	.....	0.05 [3]	0.30 to 0.50 Cr
Cr-Cu-Ni	0.12 max.	0.65 to 0.85	0.15 to 0.25	0.45 to 0.65	0.75 max.	.....	.....	0.65 to 0.85 Cr
Mn-Mo	0.25 max.	1.65 max.	0.25 max.	.....	.....	0.70 max.	0.05	S 0.06 max.
New Steel:								
Otiscoley	0.12 max.	1.00 to 1.35	0.10 max.	0.50 max.	0.10 max.	.....	0.10 to 0.14	0.10 max Cr

[1] S 0.04 max. [2] P and S aver. 0.35 to 0.55 unless otherwise stated. [3] S 0.05 max.

to 0.22 per cent, a manganese range of 1.35 to 1.55 per cent, a silicon range of 0.15 to 0.30 per cent, with the vanadium 0.08 to 0.14 per cent.

These composition ranges have been somewhat modified. The carbon range has been lowered to 0.13 to 0.18 per cent as has also the manganese to 1.20 to 1.45 per cent. There has also been a slight change in the vanadium to 0.08 to 0.12 per cent. The present physical properties in the as-rolled condition are: For material up to and including 1½ in. in thickness—55,000 lbs. per sq. in. yield point, 80,000 to 95,000 lbs. tensile strength, 18 per cent elong. in 8 in. and 50 per cent reduction of area; for material over 1½ in. thick—50,000 lbs. per sq. in. yield point, 80,000 lbs. tensile strength, 25 per cent elong. in 2 in. and 50 per cent reduction of area. These are the specifications of the Vanadium organization.

The American Society for Testing Materials has a specification for Mn-V steel for plates for boilers and other pressure vessels—A.S.T.M. 225-39T. There are two grades, A and B. The carbon in these is 0.18 and 0.20 per cent max. respectively with the vanadium 0.08 to 0.14 per cent. The manganese is 1.45 per cent max. in each.

In the intervening period since the 1938 review, large quantities of manganese-vanadium steel, particularly for ship plates, have been consumed and the prospect for its more extensive use in the Defense Program are highly favorable.

The Molybdenum Steels—Climax Molybdenum Co.

As indicated in our review in October, 1938, there are two principal types of the low alloy molybdenum steels—the C-Mo and the Mn-Mo. The S.A.E. X 4130 may be regarded as in this class also.

C-Mo: There have been no major changes in the composition or physical properties of this steel. The carbon ranges from 0.13 to 0.25 per cent, the manganese from 0.50 to 0.90 with the silicon 0.15 to 0.30 per cent. The physical properties vary with the thickness of the section being tested. There has been no major change from those previously reported. See Tables 1 and 2.

This grade of steel continues to find extensive use

in pressure vessels, boilers and for fire boxes particularly because of its inherent strength and welding properties. This steel has been recently standardized by the A.S.T.M. under specification A204-39.

Mn-Mo: The chemical composition of this grade continues with the carbon range 0.15 to 0.30 per cent, the manganese at 1.20 to 1.75 per cent, the silicon at 0.20 to 0.50 per cent and the molybdenum at 0.20 to 0.50 per cent. The average physical properties for this steel as-rolled are found in Table 2. These will also vary with the section.

The Steel Company Steels

THE STEELS OF THIS CLASS, developed and promoted by the steel companies, are reviewed in the following paragraphs.

"Cor-Ten" and "Man-Ten"—U. S. Steel Corp.

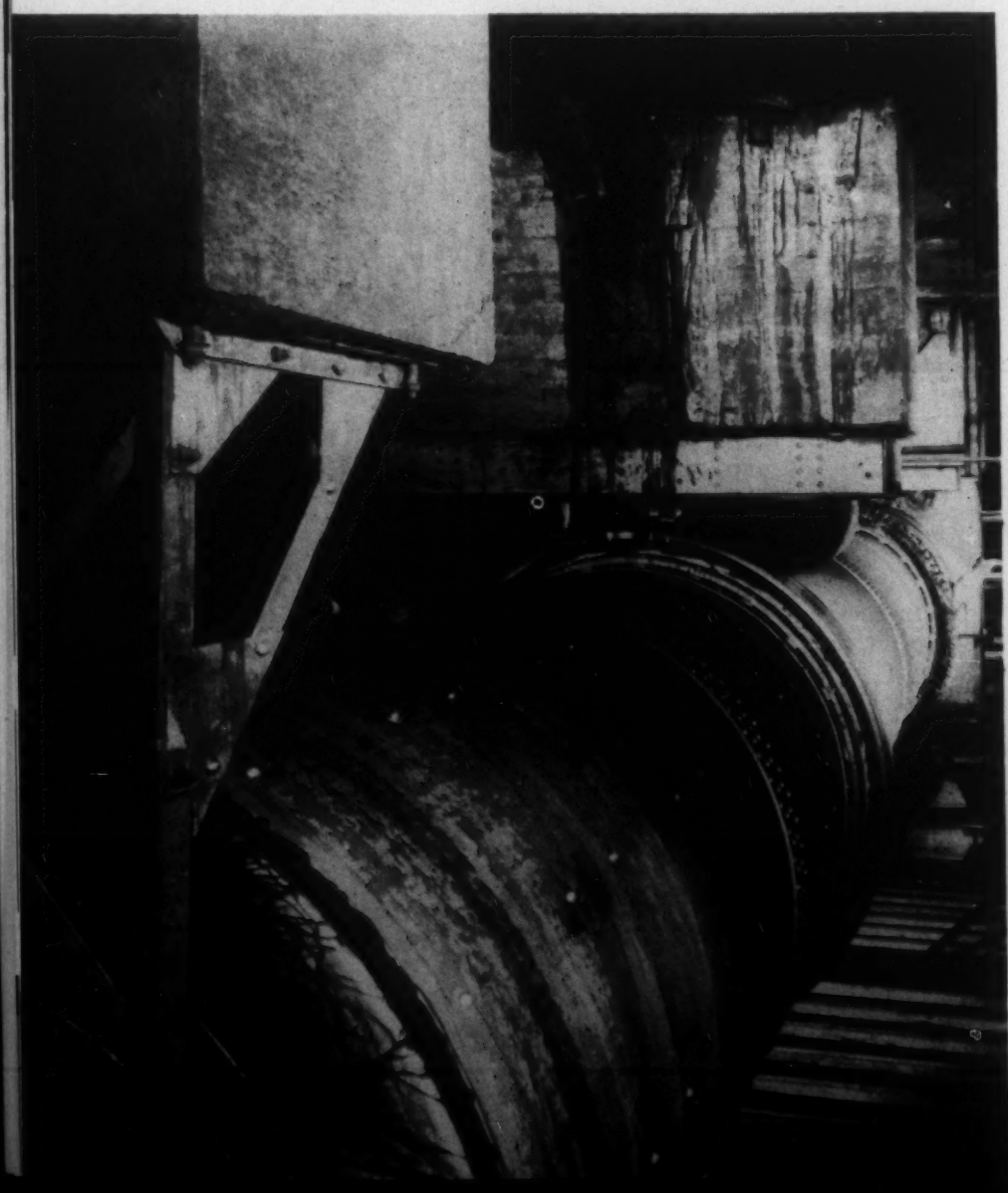
The percentage range of the specified elements in USS Cor-Ten is now carbon 0.12 max., manganese 0.10 to 0.50 per cent, silicon 0.25 to 1.00 per cent, copper 0.30 to 0.50 per cent, phosphorus 0.07 to 0.20 per cent, sulphur 0.05 max., chromium 0.50 to 1.50 per cent, and nickel 0.55 max. Changes include the raising of the carbon content, the lowering of the minimum silicon range from 0.50 to 0.25, a change in the phosphorus range, and the interjection of the nickel content.

In Man-Ten the only change in composition is a range of 1.10 to 1.60 per cent Mn instead of 1.25 to 1.70 per cent formerly. In physical properties the minimum tensile strength is now 75,000 lbs. per sq. in. instead of 80,000 lbs.

General information of importance to designing engineers and fabricators is as follows:

Properties	Cor-Ten	Man-Ten
Atmospheric corrosion resistance as compared with plain carbon steels	4 to 6	2 to 3
Abrasion resistance as compared with plain carbon steels	1.33	1.33
Charpy impact ft.-lbs., as rolled —aver. stand. 10 mm. specimen; keyhole notch 5 mm. deep	42	36
Endurance limit, lbs. per sq. in. Normalized, average	48,000	40,000
Modulus of elasticity, lbs. per sq. in.	29,000,000	29,000,000
Coefficient of expansion, per deg. F. 70 to 200 deg. F.	6.7×10^{-6}	6.5×10^{-6}

The most important field of application of the low-alloy steels is still in mobile equipment, says a statement of the Corporation. "Up to Jan. 1, 1941, we have records of 39,075 freight cars built or on order in which Cor-Ten has been used for all or part of the body construction. Cor-Ten has also been used in 1339 steam railroad passenger cars." . . . "Some of the other important applications of high tensile steels include mine cars, trucks, trailers and buses, earth moving and road building equipment,



A railroad car roof section of Armco High Tensile Steel. (Courtesy: American Rolling Mill Co.)

Part of dryer in which Inland Hi-Steel was used. (Courtesy: Inland Steel Co.)

locks and dams and blast plates and deck plates for bridges."

In the previous survey of these steels, the Steel Corporation included a grade under the name Sil-Ten. This has been dropped from the high tensile steel group. However, it is still obtainable.

Illustrations of some of the special applications of Cor-Ten are included in this article.

"Yoloy"—Youngstown Sheet & Tube Co.

Some slight changes are reported in the chemical and physical properties of Yoloy, the low-alloy, high strength steel of the Youngstown Sheet & Tube Co., Youngstown, Ohio.

A grain truck built of Armco High Tensile Steel. (Courtesy: American Rolling Mill Co.)

The carbon range has been expanded to 0.05 to 0.35 per cent (formerly 0.05 to 0.25) and the upper limit for manganese has been made 1.00 per cent instead of 0.90. A sharp change in the silicon range is 0.003 to 0.20 per cent (formerly 0.10 to 0.25). The percentages of nickel and copper remain the same, and for phosphorus and sulphur a maximum of 0.04 and 0.05 respectively has been established instead of a range of 0.035 to 0.055 per cent each.

In the physical properties experience has shown that the yield point stands at 53,000 to 85,000 lbs. per sq. in. (formerly 53,000 to 69,000); the tensile strength at 68,000 to 105,000 lbs. per sq. in. (formerly 70,000 to 95,000) and the elongation in 8 in. 1,800,000 divided by the tensile strength.

The Charpy impact values are reported on a 0.10 per cent C steel as:

+	70 deg. F.	— 130 ft. lbs.
—	100 deg. F.	— 70 ft. lbs.

The specimens used are described as 0.394 by 0.394 by 2 in. with a 45 deg. milled notch 0.01 in. bottom radius leaving 0.315 in. under notch.

Among some of the advantages claimed for Yoloy the company cites its high impact values at low temperatures. Compared with an S.A.E. 1035 steel its Charpy values are progressively higher as the temperatures increase, being 70 ft. lbs. at minus 100 deg. F. and 130 ft. lbs. at plus 70 deg. F. as compared to 5 ft. lbs. and 55 ft. lbs., respectively, for the 1035 steel. Yoloy is claimed to weld as readily as carbon steels of the same carbon and manganese content. Due to the presence of nickel and copper the resistance to corrosion over the commonly used copper-bearing steel is pronouncedly superior, it is claimed by formal tests.

"Republic Double Strength, Grades 1 and 1A"—Republic Steel Corp.

This steel was formerly called "RDS" but the Republic Steel Corp. insists that the full name—"Republic Double Strength" be used.

Changes in the past two years or so in chemical composition have been minor in nature—the nickel range is now 0.50 to 1.25 per cent instead of 0.50 to 1.50 per cent, and an upper limit of 0.04 has been placed on both the sulphur and phosphorus content. There have been no changes in the claimed physical properties.

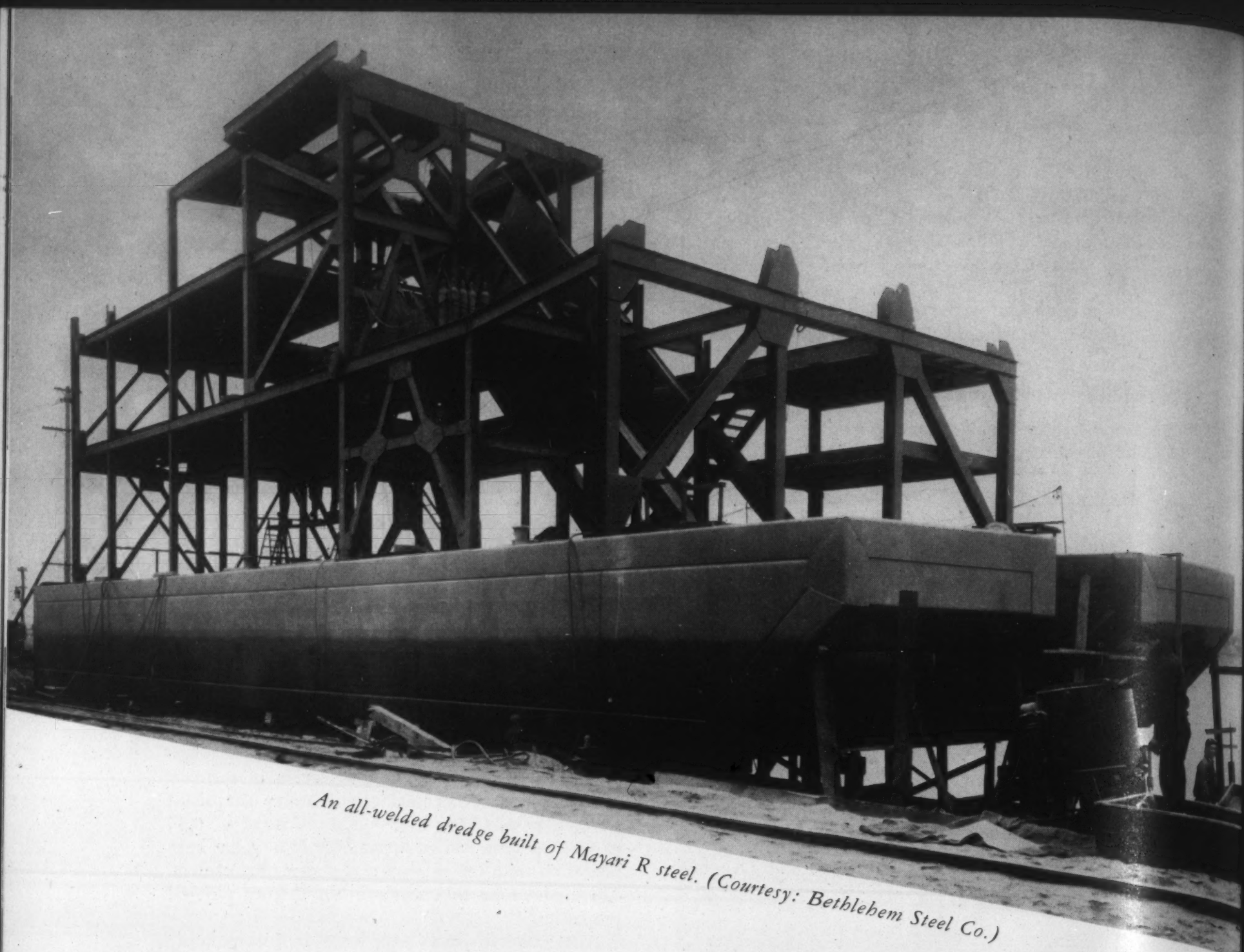
After several years' experience in incorporating these steels in various types of equipment—coal trucks and hopper cars, passenger cars, commercial trucks, street cars, locomotives, etc.—the company claims the demonstration of the high resistance to corrosion and easy weldability of these brands, as well as the withstanding of abrasion and extra years of service under severe conditions.

These advantages are claimed to be due to the special composition of copper, nickel and molybdenum which insure high tensile, high yield strength ratio, good ductility, low air-hardening properties and excellent resistance to corrosion and to abrasion.

"Inland Hi-Steel"—Inland Steel Co.

Practically no changes have been made in the chemical composition of this steel since those promulgated in our 1938 review. Sulphur is put at 0.05 maximum and it is stated that no chromium, molybdenum or vanadium are added.

There have been some alterations in the physical properties obtained as a result of its applications. The minimum physical properties and the average for ¼-in. plates are as follows:



An all-welded dredge built of Mayari R steel. (Courtesy: Bethlehem Steel Co.)

	Minimum	Aver. for ¼-in. plate
Tensile strength	70,000	74,000
Yield strength	55,000	62,000
Endurance limit	.....	49,000
Shear strength	.....	66,000
Bearing strength	.....	115,000
Red. of area	55.0	60.0
Elong. in 8 in.	20.0	24.0
Brinell hardness	.....	160.0

Data on impact resistance are also furnished by the company as follows:

Temperature, Deg. F.	Charpy Impact, Ft.-Lbs.
80	55.3
32	43.1
15	39.5
0	36.3
—10	36.8
—25	33.7
—50	30.4

It is pointed out that this steel can be readily welded by arc, acetylene, spot, resistance or flash welding and that practically no hardness adjacent to the arc welds exists. The maximum hardness in the affected zone is 183 Brinell. It is claimed that acetylene welding on this steel is easier than on mild.

Hot forming and forging present no difficulties, it is reported, and cold forming requires slightly larger radii and more power than mild steel.

Inland Hi-Steel is said to be more than twice as resistant to atmospheric corrosion as copper-bearing steel with corrosion resistance by tap water and salt water appreciably greater than plain carbon or copper-bearing steels. Corrosion tests have been made in over 50 different types of environment and it has been found, says the company, that wherever plain carbon steel will last any appreciable time, Inland Hi-Steel will last much longer. This is particularly true as regards corrosion from coal since one of the largest applications of this low-alloy steel has been in cars of equipment handling coal.

Despite its relatively low hardness, Inland Hi-Steel has been found to have excellent abrasion resistance.

"Armco High Tensile"—American Rolling Mill Co.

There have been no important changes in the composition or the physical properties since those

Table 2—Physical Properties of Present-Day Low Alloy Steels (As Rolled)

	Yield Pt.	T.S.	El. in 2 in.	Impact	Coef. of Exp.	End. Ratio	End. Limit
Early Steels:							
SAE 2115	45,000 [1]	65,000 [1]	28.0	.....	.....	.....	.....
2 to 2.5% Ni	60% of T.S.	75,000 [1]	... [2]	.....	.....	.....	.....
2 to 2.5% Ni [4]	65,000	100,000	30.0	.....	.....	.....	.....
SAE 2300	50% of T.S. [14]	90 to 115,000	... [2]	.....	.....	.....	.....
SAE 3130 [4]	65,000	95,000	25.0	.....	.....	.....	.....
SAE 3115 [4]	53,000	74,000	30.0	.....	.....	.....	.....
SAE 4630 [4]	76,000	103,000	23.0	.....	.....	.....	.....
SAE 4615 [4]	60,000	82,000	28.0	.....	.....	.....	.....
Medium Mn	Similar to Man-Ten						
Si Struc.	A.S.T.M. A94-39						
Cromansil	50,000	80,000	18.0 [6]	.....	.....	.....	.....
Mn-V [15]	55,000	80 to 95,000	18.0 [6]	.....	.....	.....	.....
Cr-V	.....	.....	.....	.....	.....	.....	.....
C-Mo	42 to 57,000	72 to 79,000	27 to 20.6 [6]	.....	.....	.....	.....
Mn-Mo	50 to 80,000	75 to 120,000	.....	.....	.....	.....	.....
SAE X 4130	70,000 [1]	90,000 [1]	20 to 10	.....	.....	.....	.....
Steel company steels:							
Cor-Ten	50,000 [1]	70,000 [1]	22.0 [1]	40.0 [7]	.....	.....	48,000 [13]
Man-Ten	50,000 [1]	75,000 [1]	20.0 [1]	30.0 [7]	6.5×10^{-6}	0.50	40,000 [13]
Yoloy	53 to 85,000	68 to 105,000	... [16]	... [17]	.....	.....	.....
R.D.S. 1	55,000 [1]	70,000 [1]	25.0	.....	.....	.....	.....
R.D.S. 1A	70,000 [1]	90,000 [1]	15.0	.....	.....	.....	.....
Hi-Steel	55,000 [1]	70,000 [1]	20.0 min. [6]	55.3 to 30.4 [7]	.....	.....	49,000
Armco High Tensile	50,000 [1]	65 to 75,000 [1]	25.0 to 28.0	130.0 [9]	.....	.....	43 to 50,000
Jal-Ten	50,000 [1]	80,000 [1]	20.0 [1]	40.0 [9]	.....	.....	0.50 T.S. [1]
Granite City HS1	No report						
Central High Tensile	No report						
Konik	No report						
Mayari R	50,000 [1]	70,000 [1]	22.0 [1]	75.0 [9]	.....	0.70	50,000
A.W. Dyn-El	52 to 60,220	68 to 78,000	25.0 [1]	3550 [11]	.....	.....	45,000
N-A-X High Tensile	50 to 65,000	70 to 85,000	32.0 to 50.0	59 [7]	.....	.....	.....
Lukens Steels:							
Ni Steel (3 grades)	55% of T.S.	65 to 87,000	... [18]	.....	.....	.....	.....
C-Mo (3 grades)	55% of T.S.	65 to 87,000	... [18]	.....	.....	.....	.....
Cr-Mn	55% of T.S.	90,000 [1]	18.0	.....	.....	.....	.....
Cr-Cu-Ni	55% of T.S.	65,000 [1]	25.0	.....	.....	.....	.....
Mn-Mo	60 to 75,000	85 to 95,000	.....	.....	.....	.....	.....
New Steel:							
Otiscoloy	50 to 70,000	70 to 85,000	33.0 to 44.0	35 [7]	.....	.....	48,000

[1] Min. [2] 1,600,000 ÷ T.S. 20% min. [3] 1,700,000 ÷ T.S. [4] Average results. [5] 1,600,000 ÷ T.S. [6] In 8 in. [7] Charpy. [8] 73 deg. F.; 48 at —40 deg. F. [9] Izod. [10] 1,500,000 ÷ T.S. pct. min. (8 in.). [11] Izod (Room Temperature) ft. lbs. per sq. in. [13] Normalized. [14] 55,000 min. [15] Up to and inc. 1½ in. thick. [16] 1,800,000 ÷ T.S. [17] Charpy 130 at 70 deg. F. and 70 at —100 deg. F., C = 0.10. [18] 1,650,000 ÷ T.S. (8 in.).

made public in October, 1938.

The principal change has been in the name—it is no longer known as "Armco H. T.-50." The designation of "Armco High Tensile" has been adopted.

The strength-giving elements which help make up Armco High Tensile also impart remarkable corrosion resistance to the material, says the company. No one element suffices. Armco research workers have learned, after many years of extensive and careful study, that "phosphorus, nickel and copper, and the like, carefully proportioned achieve remarkable results."

In weldability, unusually excellent welding properties have been found to characterize this steel.

"Jal-Ten"—Jones & Laughlin Steel Corp.

This company reports that the only change in the specifications for "Jal-Ten" is that the sulphur is now specified as 0.050 per cent maximum.

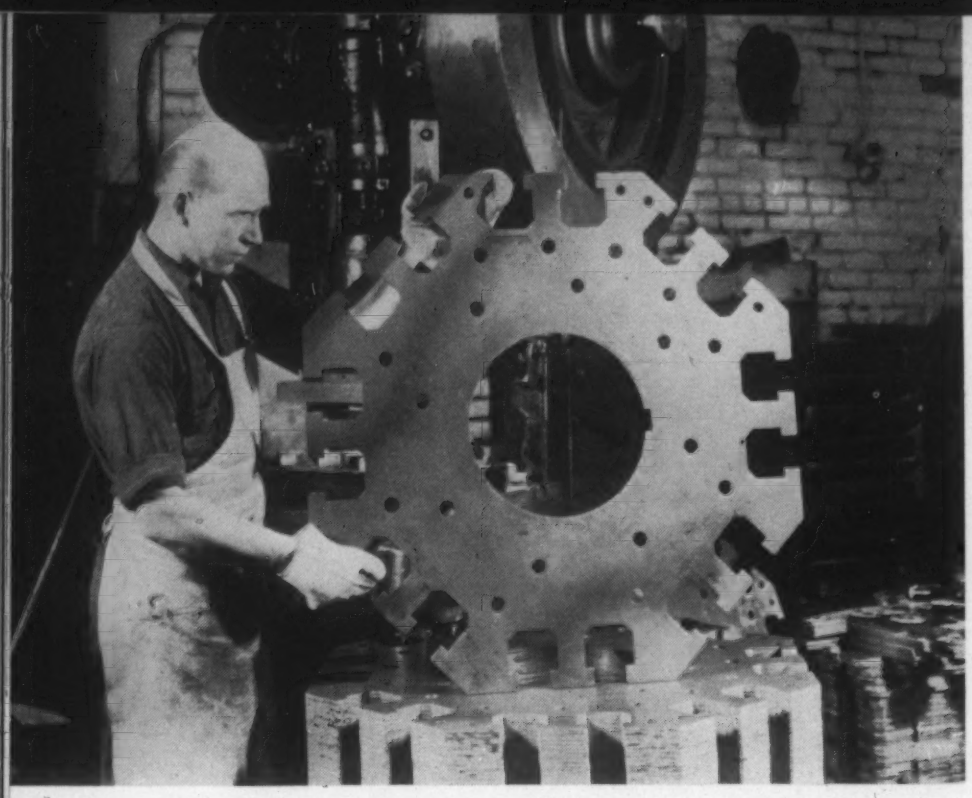
The information published in the last review still holds.

"Mayari R"—Bethlehem Steel Co.

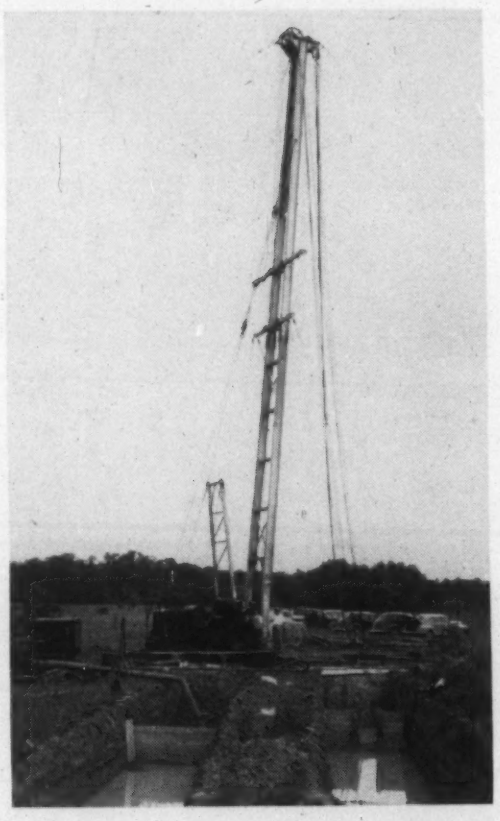
In our review of October, 1938, "Mayari R" steel was designated as one of new steels and fairly full data were published. This steel is a chromium-nickel-copper steel.

A few changes have been made in the chemical specifications—the carbon is lowered from a maximum of 0.14 per cent to 0.12 per cent, the phosphorus range has been changed from 0.04 to 0.12 to 0.08 to 0.12 per cent, and the sulphur from a range of 0.035 to 0.055 to a maximum of 0.05 per cent. Minor changes have been made in the physical characteristics.

The company reports that, since the information given out in 1938, the applications of Mayari R have been extended to many new fields and ample opportunity has been afforded to study its properties and performance under a wide variety of conditions. Its formability and weldability are favorably commented upon and other reports from numerous sources confirm the experience of the company's own



Rotor blades for 7500 kva. synchronons condenser recently built for a Bonneville Dam transmission line. Due to the large size and comparatively high speed of this unit, the stresses set up in the T-tail slots are of such order that a material of high strength is desirable. Mayari R steel was selected after tests had shown that its magnetic and physical properties were satisfactory for this service. Ease of fabrication was also a requirement, as it is extremely important to avoid even minute cracks in the punched slots. (Courtesy: Bethlehem Steel Co.)



Portable drilling rig of Mayari R steel. The total weight of this rig, including skids, mast and crown block, is about 30,000 lbs., a saving of nearly 40 per cent over ordinary carbon steel. (Courtesy: Bethlehem Steel Co.)

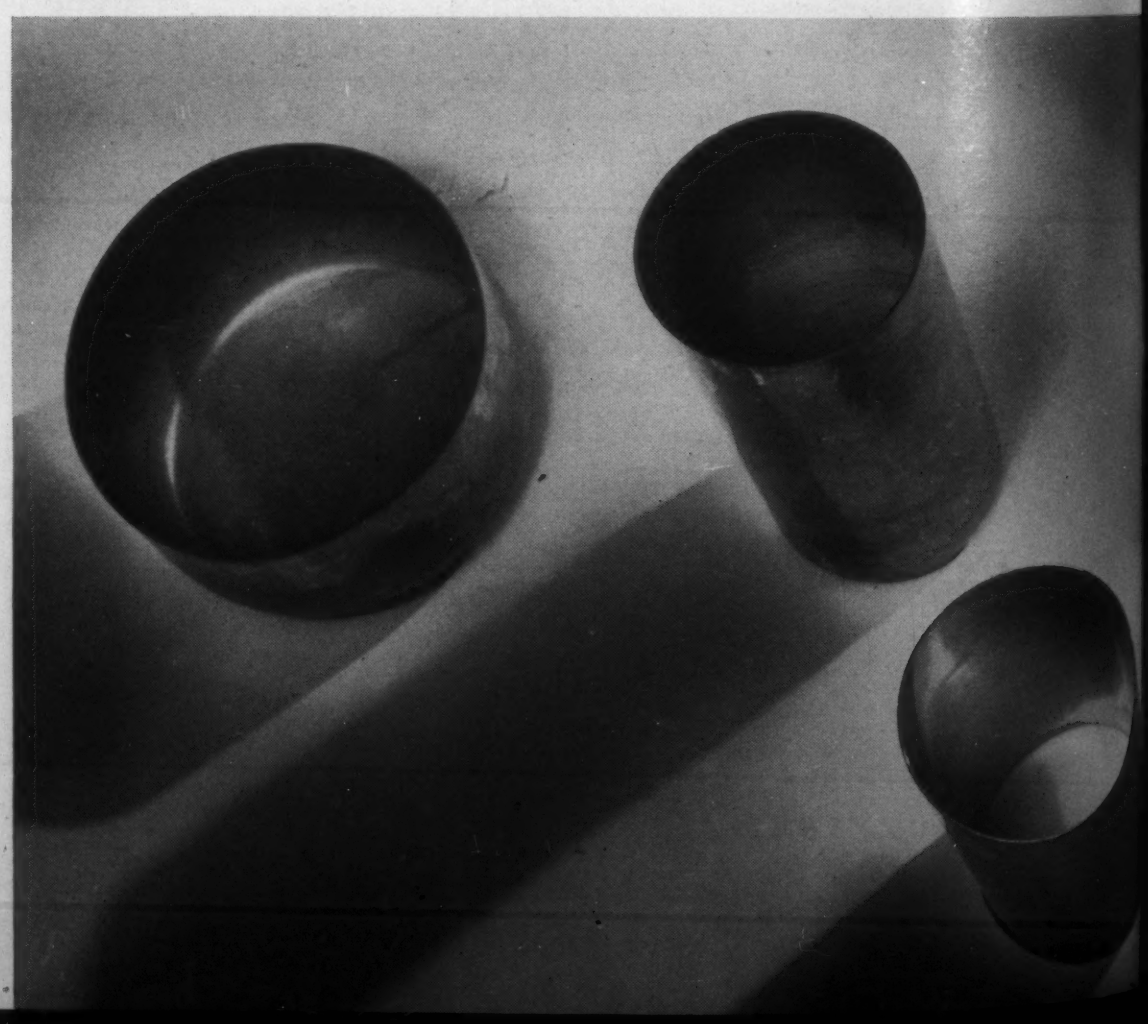
shop men that Mayari R can be welded as readily as ordinary carbon steel. Tests on the resistance of this steel to atmospheric corrosion, extending over more than 4 yrs., continue to show the same trend as indicated in former reports—a resistance to atmospheric corrosion 4 to 6 times that of mild carbon steel.

The major output for Mayari R steel is reported as freight cars, passenger cars, mine cars, trucks and trailers of all types, as well as appreciable quantities going into bridge construction as plates, shapes, bolts and rivets. Other applications include hoists, dipper sticks, mine cages, oil drilling rigs, blast plates, bridge deck plates, cinder pits, metallurgical fans, dust catching equipment, stacks, roofs, coaling stations, etc. A few marine uses include a dredge (herewith illustrated), deck plates, tank partitions and hold plates.

"A. W. Dyn-El"—Alan Wood Steel Co.

No changes in the chemical composition or physical properties of the "Dyn-El" steel, produced by the Alan Wood Steel Co., Conshohocken, Pa., have been made since the inauguration of this steel over 3 yrs. ago.

The company states that it has been encouraged by the rather general adoption of the low-alloy, high strength steels on U. S. Ordnance work under strict specifications regarding physical and welding properties. The general indications are, it is stated, that as the Ordnance engineers have more time, more equipment will be designed for this type of steel.



The cylinders are 6½ in. deep and 3¼ in. in diameter, with a wall thickness of 0.041 in. They were drawn from a flat blank of N-A-X High Tensile steel in eight draws with no intermediate annealings. (Courtesy: Great Lakes Steel Corp.)

Quite a large tonnage of A. W. Dyn-El steel has been used for this purpose with successful results. It has been used by various arsenals for certain types of equipment and also by private manufacturers having contracts with the War Department.

As in the past this steel is being used in commercial applications for trucks, buses, etc., even on a larger scale than formerly, it is reported.

"N-A-X High Tensile"—Great Lakes Steel Corp.

In 1938 this low-alloy or mild alloy steel was sold under the name—"Ductiloy." In 1940 this designation was changed to—*"N-A-X High Tensile."*

In the review published in October, 1938, only a few preliminary facts were available but in the November issue of METALS AND ALLOYS, page MA 685, the physical properties were published. These values for 1938 and 1940 are as follows, only slight changes having been made:

	In 1938	In 1941
Carbon	0.10 to 0.18	0.10 to 0.18
Silicon	0.80 to 0.90	0.65 to 0.90
Zirconium	0.15 to 0.25	0.10 to 0.15
Chromium	0.50 to 0.65	0.50 to 0.65
Manganese	0.60 to 0.75	0.60 to 0.75
Nickel	0.15 to 0.25	0.10 to 0.25
Sulphur	0.04 max.	0.04 max.
Phosphorus	0.04 max.	0.04 max.
Copper	Residual	0.25 max.
Molybdenum	Residual	0.15 max.
Yield point, lbs. per sq. in.	49 to 67,000	50 to 65,000
Tensile strength, lbs. per sq. in.	78 to 88,000	70 to 85,000
Elong. in 2 in. per cent	32.0 to 50.0	50.0 to 32.0
Red. of area, per cent	.....	74.0 to 60.0

A statement from this company is to the effect that this steel has unusually good notch impact values at normal and extremely low temperatures, both in the parent metal and as welded. It also has most outstanding fatigue resisting properties as reported from the results of numerous tests. Its ductility, also permits its fabrication into difficult parts heretofore considered only possible with mild carbon steels. Some evidence of the forming properties is revealed by illustrations.

A car wheel, about 20 in. in diameter, made from 1/4-in. N-A-X High Tensile in two draws and a curling operation, no annealing being involved. (Courtesy: Great Lakes Steel Corp.)

The Unreported Steels In 1938

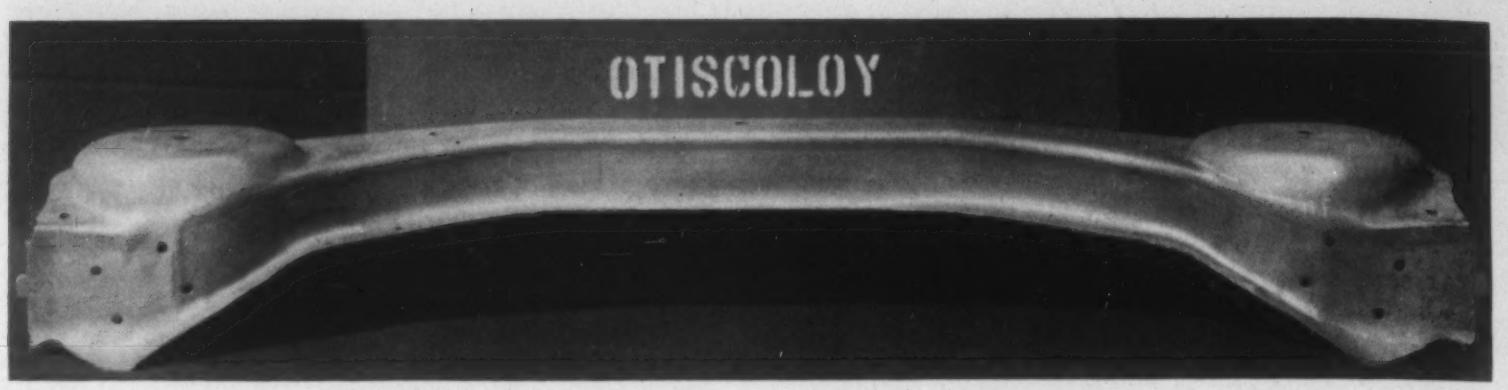
In the 1938 survey there were three steels, formerly listed under the low-alloy high strength classification—"Granite City HS1 and HS2," "Centralloy," and "Konik"—concerning which no reports were received. This year some data are available.

"Granite City HS1": The Granite City Steel Co., Granite City, Ill., reports that it still makes and sells a small quantity of Granite City HS1, the analysis of which remains the same as in other surveys. This steel is 0.14 C, 0.70 to 0.90 Mn, 0.15 to 0.20 Si, 0.25 to 0.30 Cu and 0.12 per cent Cr.

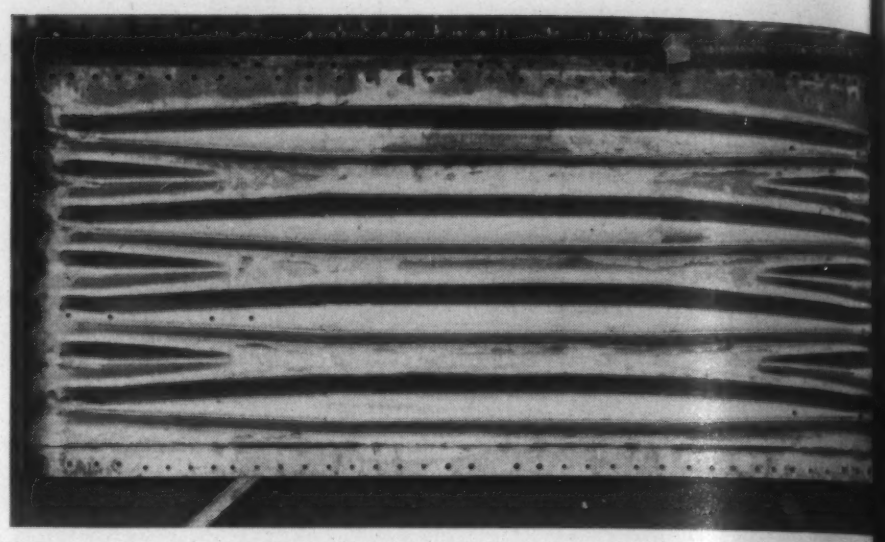
The company states that when it introduced its Hi-Yield steels, physical properties were of primary consideration. Later corrosion resistance became of great importance. A new analysis for the company's steel, based on extensive corrosion tests of many of the steels, is being developed, but is not yet ready for announcement. A better steel than the present one is promised.

"Konik": The Continental Steel Corp., Kokomo, Ind., still produces this steel, a low alloy Cr-Ni-Cu steel in the form of sheets and wire.

Central High Tensile: The Central Iron & Steel Co., Harrisburg, Pa., which formerly offered "Centralloy," today makes a high tensile steel to which no special trade name has been assigned. No further details are available. Statements in the trade are that it contains about 1 per cent Ni and 1 per cent Cu.



A difficult frame stamping made from Otiscoloy. (Courtesy: Otis Steel Co.)



Corrugated end for a gondola car made from Otiscoloy. (Courtesy: Otis Steel Co.)

One New Steel

IN OUR REVIEW IN 1938 we were able to announce the introduction of three new low-alloy or "mild alloy" steels as having been developed since 1936. In the period since 1938 only one new steel of this class has been put on the market—"Otiscoloy."

The Lukens Steel Co. lists certain of its products as low-alloy, high tensile steels; these are described in later paragraphs.

"Otiscoloy"—Otis Steel Co.

Late in 1940 the Otis Steel Co., Cleveland, announced a new steel under the name of "Otiscoloy." According to data furnished by the company, the chemical composition is as follows:

Carbon	—	0.12 max.
Manganese	—	1.00 to 1.35
Phosphorus	—	0.10 to 0.14
Silicon	—	0.10 max.
Copper	—	0.50 max.
Nickel	—	0.10 max.
Chromium	—	0.10 max.

The physical properties in the "as-rolled" condition are as follows:

Yield strength	—	50-70,000 lbs. per sq. in. (depending on gage)
Tensile strength	—	70-85,000 lbs. per sq. in. (depending on gage)
Elong. in 2 in.	—	30 to 44 per cent
Elong. in 8 in.	—	22 to 30 per cent
Red. of area	—	55.0 per cent min.
Charpy impact at 75° F.	—	35 ft.-lbs. min.
Charpy impact at —50° F.	—	15 ft.-lbs. min.
Endurance limit	—	48,000 lbs. per sq. in. min.
Shearing strength	—	60,000 lbs. per sq. in. min.

Further data on this steel, furnished by S. W. Whitelaw, chief metallurgist of the company, are as follows:

The minimum elongation value of 30 per cent for a steel of such strength indicates the successful application of Otiscoloy where stringent forming or drawing properties are necessary; the slight difference in formability between Otiscoloy and plain carbon steels is more than counterbalanced by the greater strength obtained with the former steel.

As shown by the Charpy impact test results, Otiscoloy is admirably suited for use where sub-zero temperature would be encountered. The absence of low temperature brittleness favors its application under shock-producing loads at temperatures below normal.

The fact that the endurance limit of Otiscoloy is about 75 per cent greater than that of plain low carbon steels and 50 per cent greater than that of medium carbon steels opens up another field. An interesting test was made on strength and on fatigue resistance between two automobile frames, one made up of Otiscoloy, the other of 0.20 to 0.30 per cent C steel. These frames were subjected to a standard fatigue resistance experiment made on all designs of cars fabricated by the particular plant where the test was made. The results proved the Otiscoloy frame withstood almost double the cycles required to cause failure in the carbon frame, or in other words, the standard frame, enduring only 69,920 cycles, was approximately only 50 per cent as resistant to fatigue failure as the Otiscoloy frame which lasted for 135,910 cycles.

In conjunction with this test, information as to weldability was also obtained. The Otiscoloy frame suffered no failures adjacent to the welded areas whereas, with the standard frame, at least three such points of failure were noted; this property, whereby Otiscoloy does not air harden adjacent to welded areas, becomes of value when it may be assumed that any subsequent stress relieving operation may be omitted. This property is, of course, significant to any fabricator inasmuch as the elimination of this extra step works to his advantage.

It has been found that Otiscoloy welds are capable of taking a free bend through 180 deg. without failure. Charpy impact tests across the entire welded section do not disclose any appreciable variation.

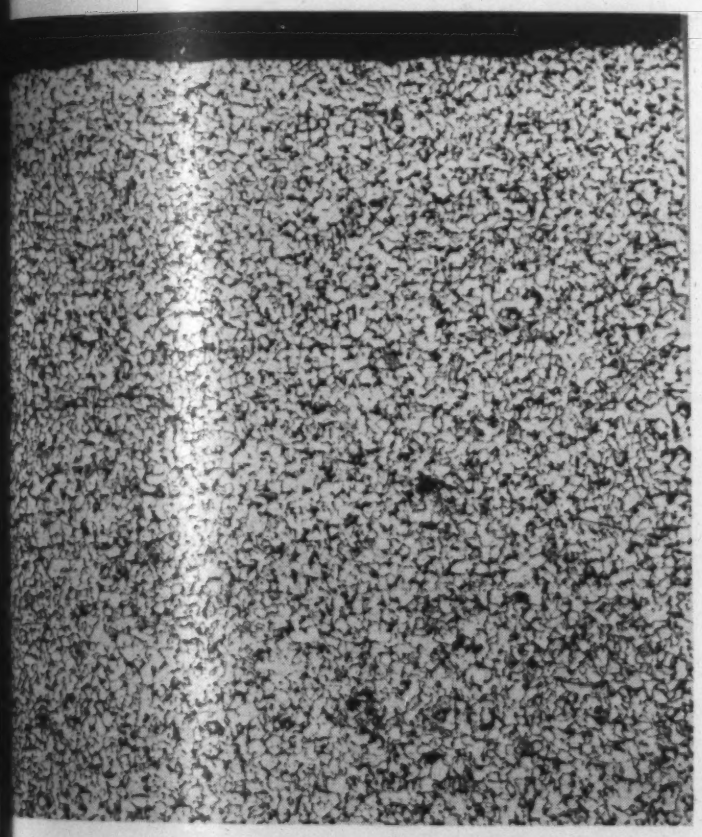
The following table lists the impact values found on some welded 3/4-in. thick plate at the points designated:

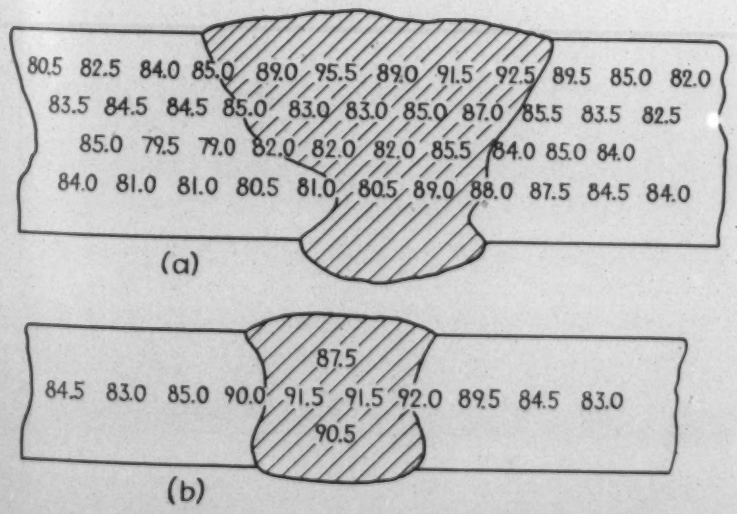
Location of Notch	Charpy Ft. Lbs. Cellulose Coated Rod
In parent metal	37.0
In weld metal	38.0
In weld junction	39.0
In affected zone	38.0

As examples of the hardness obtained on welded sections, some illustrations show the very uniform temper across such a section. Readings were taken at 1/8 in. intervals. These experiments bear out the total absence of any brittle zone commonly produced in welding many metals: likewise, the freedom from excessive variation in hardness can be seen.

Among other desirable properties, Otiscoloy has better than average in resistance to abrasion and corrosion. Its corrosion resistance is from four to six times that of plain carbon steel and from two to three times that of copper bearing steels.

Characteristic structure of Otiscoloy. (Courtesy: Otis Steel Co.)





Showing the uniform temper across welded sections. Upper in 3/4-in. plate and lower 1/4-in. Readings taken at 1/8-in. intervals.

Several Types—Lukens Steel Co.

The Lukens Steel Co., Coatesville, Pa., offers several types of low alloy high strength steels included in which are a nickel steel, a carbon-molybdenum steel, a chromium-manganese steel, a chromium-copper-nickel steel, a chromium-manganese-silicon steel ("Cromansil") and a manganese-molybdenum steel.

The nickel steel has a maximum carbon content of 0.25 per cent and maximum manganese of 0.80 per cent; the nickel range is 2.00 to 2.75 per cent with the silicon at 0.15 to 0.30 per cent. The carbon-molybdenum brand is substantially the same as the standard of this type—C 0.28 max., Mn 0.50 to 0.90, Si 0.15 to 0.30 and Mo 0.40 to 0.60 per cent. The chromium-manganese steel is specified as 0.35 to 0.45 C, 0.80 to 1.00 Mn, 0.15 to 0.40 Si and 0.30 to 0.50 per cent Cr. The Cr-Cu-Ni steel is specified as 0.12 C max., 0.65 to 0.85 Mn, 0.15 to 0.25 Si, 0.45 to 0.65 Cu, 0.75 max. Ni and 0.65 to 0.85 per cent Cr. The Cromansil steel is the same as A.S.T.M. specification A-202. The Mn-Mo steel is reported as having maximum ranges of 0.25 C, 1.65 Mn, 0.25 Si, 0.70 Mo, 0.05 and 0.06 per cent P. These and other properties of these steels will be found in the tables.

Some Articles for Reference

"Trends in the Metallurgy of Low Alloy, High Strength Structural Steels" by H. W. Gillett, Battelle Memorial Institute, Columbus, O. A.I.M.E. February, 1936, meeting.

"Choosing a Composition for Low-Alloy, High Strength Steel" by S. Epstein, J. H. Nead and J. W. Halley. A.I.M.E. February, 1936, meeting.

"Carbon and Low Alloy Steels" by Edwin F. Cone, *Metals and Alloys*, New York. Paper before A.S.T.M. Spring Committee Meetings, Pittsburgh, March 4, 1936.

"Low Alloy, High Yield-Strength Structural Steels—An Extended Abstract." *Metals and Alloys*, Vol. 7, March, 1936, pages 77 to 84.

"Physical Properties of Four Low-Alloy High Strength Steels" by W. L. Collins and T. J. Dolan, *Proc. Am. Soc. Testing Materials*, Vol. 38, Pt. II, 1938, p. 157.

"The Present Status of the Low-Alloy, High Strength Steels—A Survey," *Metals and Alloys*, Vol. 9, October, 1938, pages 243 to 254.

Electrical Heat Treatment of Rivet Studs

by L. C. CONRADI

Technical Research Manager,
International Business Machines Corp.
Endicott, N. Y.

Direct-resistance heaters of the Berwick type are commonly regarded as "forging heaters" because they were developed for heating bar stock for forging or upsetting—as described in our October, 1937, issue, page 281. Recently, however, in keeping with the trend toward rapid "selective" heating (of which automatic surface-hardening by induction is characteristic) the Berwick heaters have been increasingly applied for heating restricted portions of small parts for heat treatment—either hardening or softening—on a high-production scale.

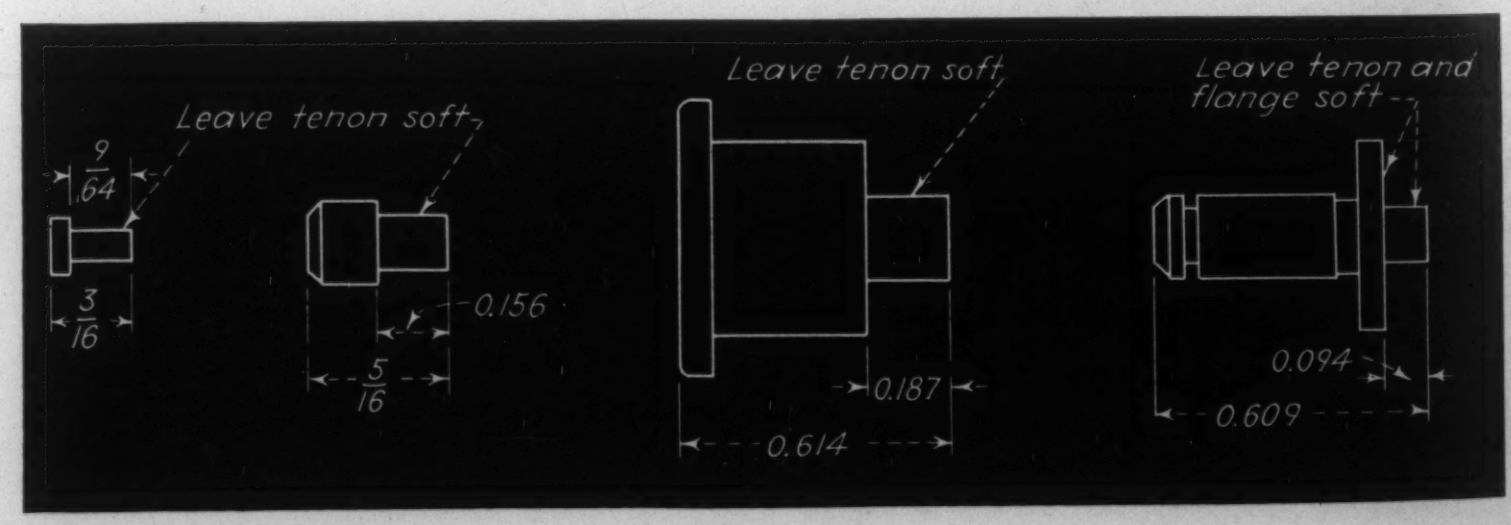
In this very practical article Mr. Conradi describes the use of a resistance heater for softening the tenons of certain case-hardened rivet studs, as well as the use of an induction heater for selective hardening of the heads and bodies of others.—The Editors.

EVEN THOUGH EXTENSIVE USE is made of the various types of welding and brazing in the manufacture of electric accounting and time recording equipment, riveting still continues as one of the important methods of assembly. Rivet studs which are hardened to meet service requirements must have soft tenons to permit proper flow and shaping of the metal under blow of the rivet hammer. Unless tenons are sufficiently soft, assemblies, even though apparently rigid at first, tend to become loose under service conditions.

Fig. 1 illustrates the type and variety of rivet studs which require hardening. These studs are made of S.A.E. X 1112 steel and are heat treated in activated salt baths to obtain whatever case depths are desired. Case depths are in the range of 0.001 in. max.; 0.002-0.003 in.; 0.003-0.005 in.; 0.006-0.008 in.; 0.012-0.015 in.; and 0.016-0.020 in. depending upon the nature of the service requirements which are to be met. Manufacturing quantities range from 300 to 50,000 pieces and yearly production quantities range from 1,000 to 100,000 pieces. Thus, all told, "leave tenon soft" presents quite a sizable job.

For many years a method of selective copper plating of the tenons in special trays, before case harden-

Fig. 1. Shapes and dimensions of some of the rivet studs that require treatment. The 3 rivet studs at the left are carburized and hardened, and the tenons then softened by resistance heating; the rivet stud at the extreme right is carburized and pot-cooled, and then the body and head are hardened by induction heating.



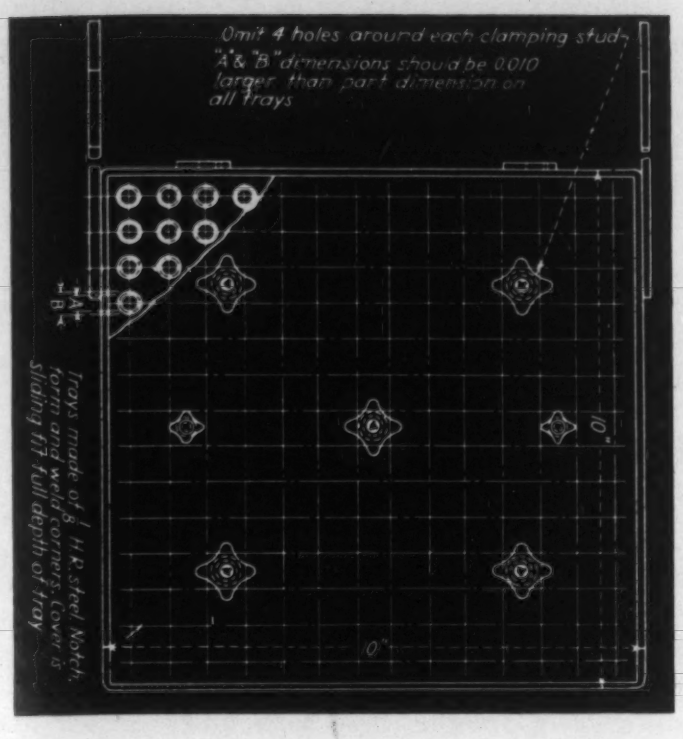

Omit 4 holes around each clamping stud
"A" & "B" dimensions should be 0.010 larger than part dimension on all trays
Trays made of 1/8 H.R. steel Notch, form and weld corners. Cover as shown fit full depth of tray

Fig. 2 (left) General design of the plating-trays usea in the old copper-stop-off method of selective carburizing.

Fig. 3. (below) A view of one of the copper-plating trays loaded with about 600 rivet studs, with the tenons visibly projecting.

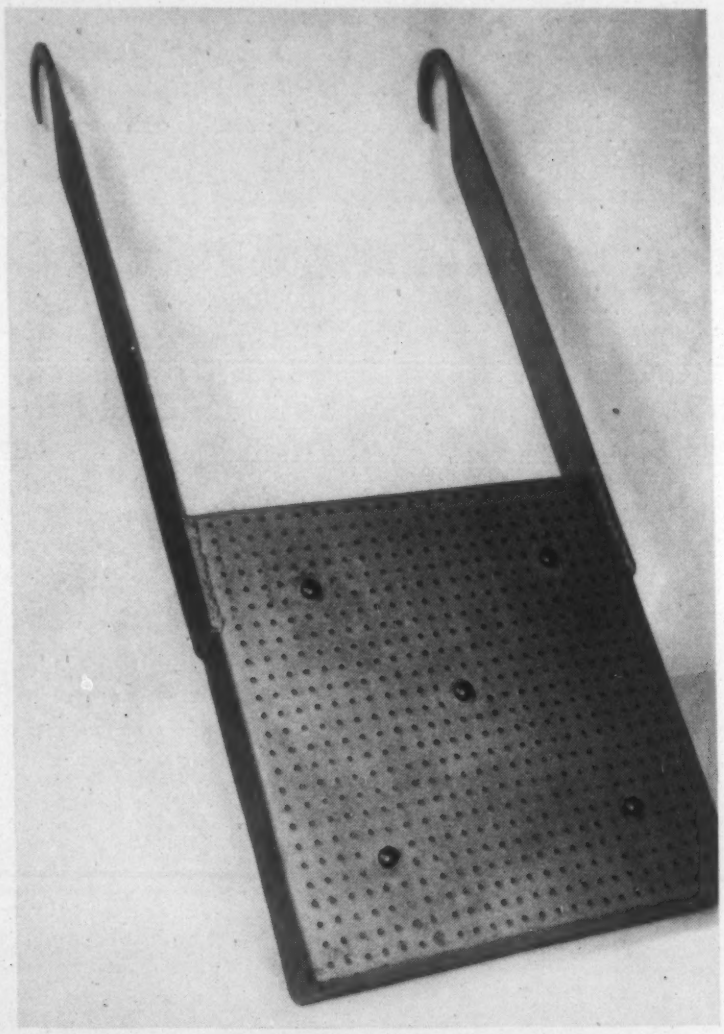
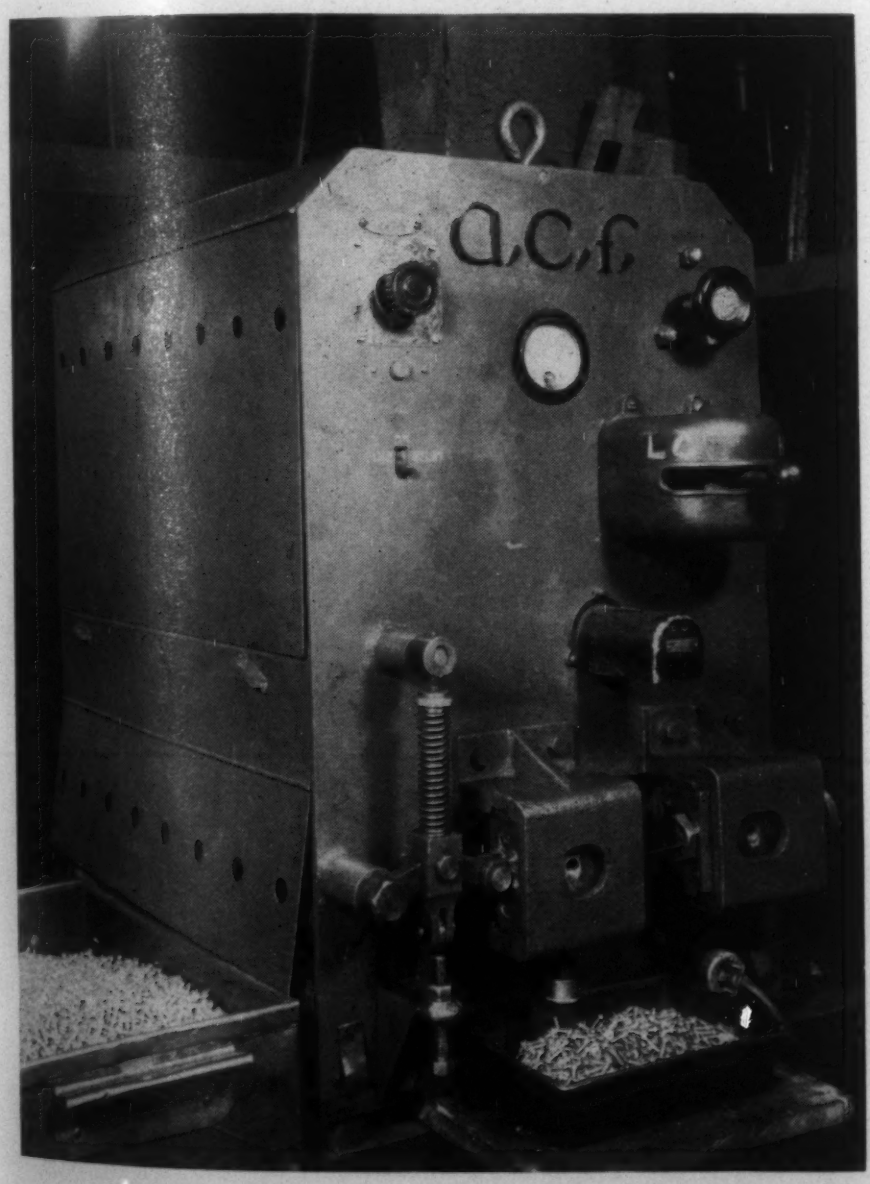


Fig. 4. A view of the Berwick heater used for direct-resistance heating of the tenons.



ing, was employed with good results. Fig. 2 illustrates the construction of the trays, showing how the holes are drilled and counter-bored to accommodate various sizes of rivet studs. Fig. 3 is a view of a loaded tray, with the tenons projecting.

This method required the following operations:

1—Insert rivet studs from inside the tray until all holes are filled.
2—Fill inside of tray with finely divided brass chips, covering up the rivet studs.
3—Apply the metal back cover and tighten it in position by means of the wing nuts.
4—Suspend the loaded tray in the cyanide copper tank and plate the projecting tenons to a thickness of 0.0008 to 0.001 in. of copper.
5—Remove tray from plating tank and rinse.
6—Remove metal back cover and shake out the rivet studs and brass chips.
7—Separate rivet studs from brass chips by means of a sieve.

Some time ago this selective copper plating method was replaced by two improved methods; namely,

selective "annealing" of the tenon by electric contact resistance heating and selective hardening of the rivet body by high frequency induction heating.

For the selective annealing of tenons after hardening the entire stud, a Berwick electric contact resistance heater (made by American Car and Foundry Co., New York), shown in Fig. 4, is used. The heater is provided with various types of interchangeable jaws and jaw tips to accommodate the various sizes of rivet studs (See Fig. 5). These jaws and jaw tips were originally made of copper but are now made of beryllium-copper and heat treated to approximately 40 Rockwell "C." Regrinding and replacement of jaws and jaw tips has thus been cut down to a minimum.

Fig. 6 shows a rivet stud being held between the jaws. A good operator can do 700 to 1200 pieces per hr. The annealing (or, rather, the tempering) of the tenon is done at approximately 900 to 1000 deg. F. A higher temperature approximating 1400 deg. F. would result in air hardening, thus leaving the tenon too hard. Although the heater is equipped with an electric eye and a timer, at the low temperature of 900 to 1000 deg. F. these cannot be used. The entire procedure is controlled by the operator. The sequence of operations is as follows:

1—Pick up rivet stud and hold between jaws.
2—Depress foot pedal to close jaws.
3—Watch for proper heat color to develop and depress pedal to open jaws.
4—Allow rivet stud to drop out into a shallow pan.

Resistance Heating

A rivet stud having a short tenon and large shoulder as that at the extreme right of Fig. 1 cannot be held between the jaws of a Berwick heater. It can, however, be treated very readily by using high-frequency induction heating and a special holding fixture. Fig. 7 shows such a fixture, consisting of a transite disc with holes drilled and counterbored to accommodate the tenon and

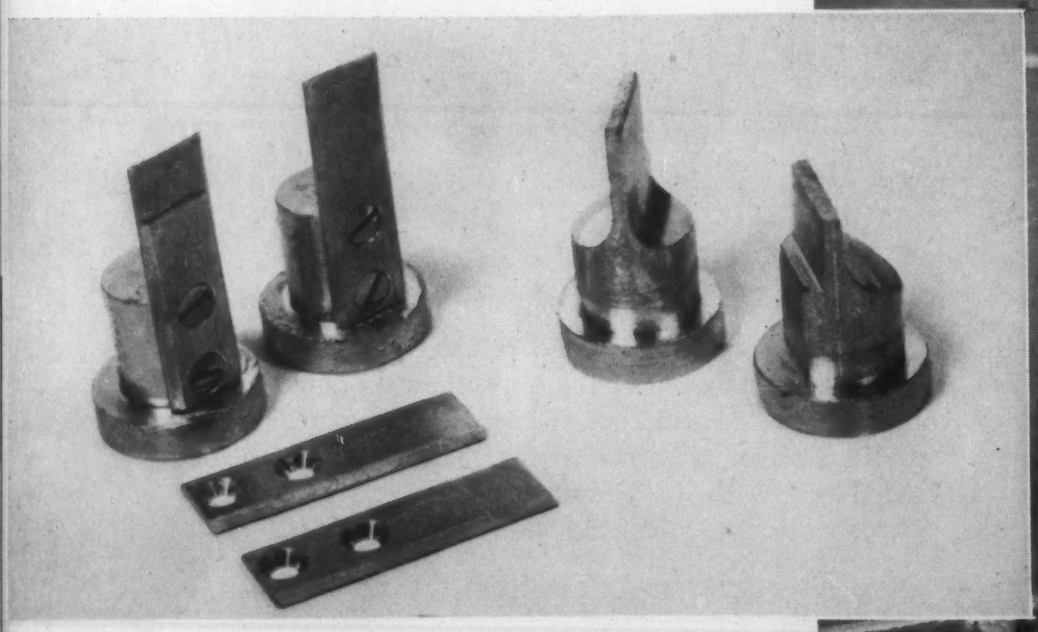


Fig. 5. Some of the interchangeable jaws and jaw tips (of heat-treated beryllium-copper) required for various sizes of rivet studs.

Fig. 6. The simple manual operation by which the rivet studs are held between the jaws of the heater.

shoulder, loaded with parts.

After carburizing to a desired depth of 0.005 to 0.010 in.; 0.010 to 0.015 in.; or 0.015 to 0.020 in. and cooling in the pot the rivet studs are processed as follows:

1—Load rivet studs in the fixture.
2—Hold loaded fixture in position in the heating coil. (See Fig. 8).
3—Heat to 1400 to 1450 deg. F. and quench.

The heat is applied to the body and head of the stud only, thus leaving the tenon absolutely soft. The instrument in the background of Fig. 8 is an electronic timer for controlling heating periods up to 20 sec. The heating time for this particular stud is 12 sec. and with two holding fixtures a production of 700 pieces per hr. is easily possible. The high frequency current is generated by a Lepel 6 k.w. spark gap converter, as made by Lepel High Frequency Laboratories, Inc., New York.

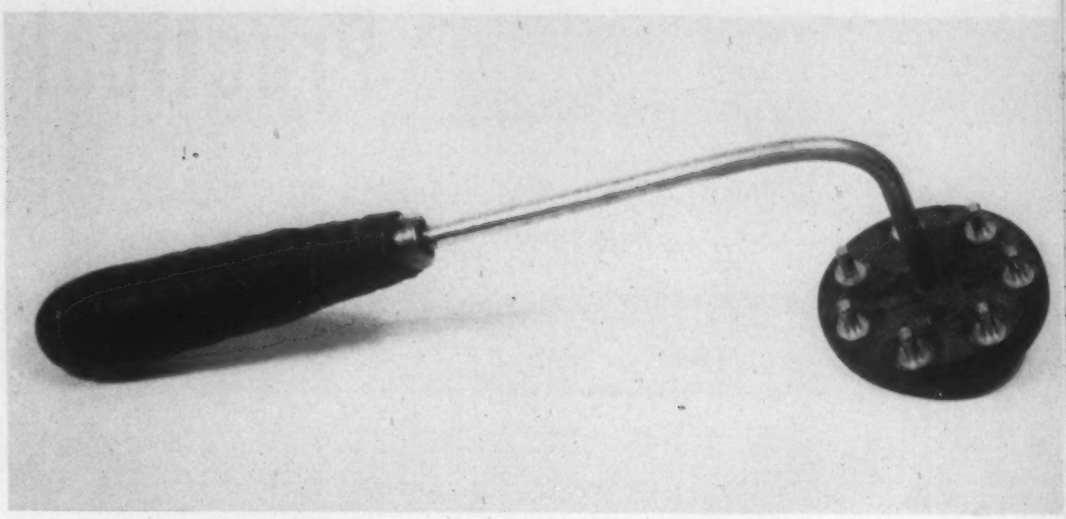
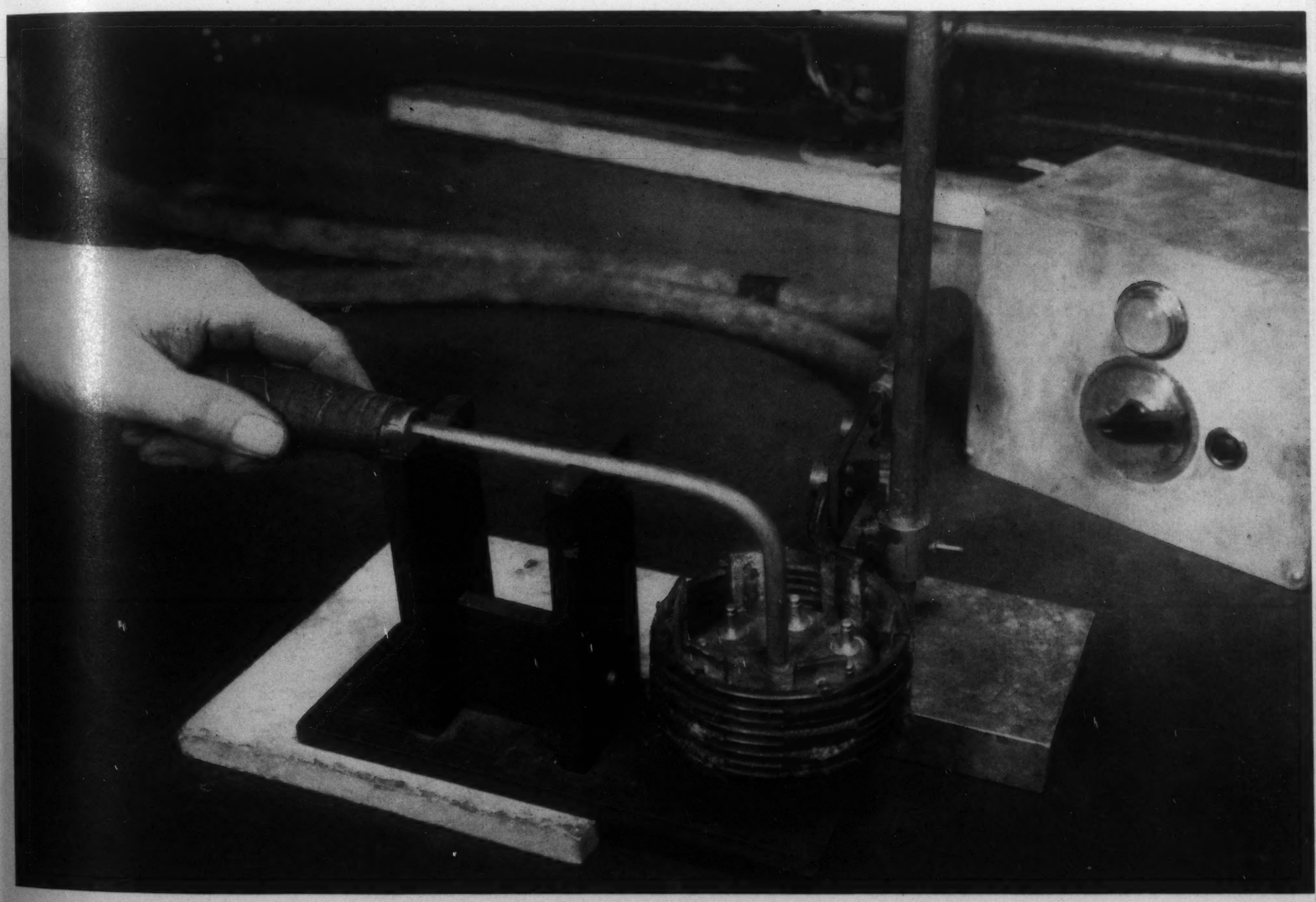


Fig. 7. Special holding fixture (loaded with parts) used for hardening the bodies and heads of short-tenoned rivet studs in a Lepel induction heater.

Fig. 8. The high-frequency induction coil, jig and holding fixture in operation, induction-hardening the rivet studs.



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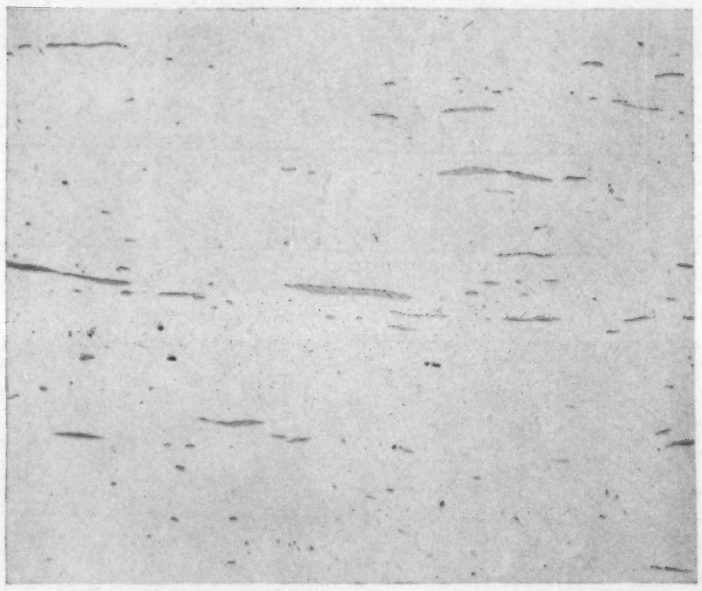


Fig. 30. Unetched structure of a free-cutting stainless steel containing 0.10 per cent C, 12 per cent Cr and 0.30 per cent S. Gray areas are sulphide particles which have been elongated during hot rolling operations. Mag. 200X.

The structural characteristics of the free-cutting hardenable stainless steel alloys are similar in all respects to the counterpart having normal sulphur (under 0.03%) content, except for the presence of sulphide particles in the metal matrix (Fig. 30). These particles, essentially non-metallic in nature, exert no effect on the structural changes of the alloy, as they are quite refractory and remain unchanged during heat-treating operations. However, at forging and rolling temperatures they are plastic and become elongated in the direction of metal flow.

The Low Carbon Steels

Although the low carbon straight chromium stainless steels, containing between 14 to 21 per cent Cr are regarded as ferritic in nature and, consequently, non-hardenable by heat treatment, it is possible to effect some hardening by quenching from high temperatures. As shown by Fig. 34, if the carbon content is extremely low, the alloy undergoes no trans-

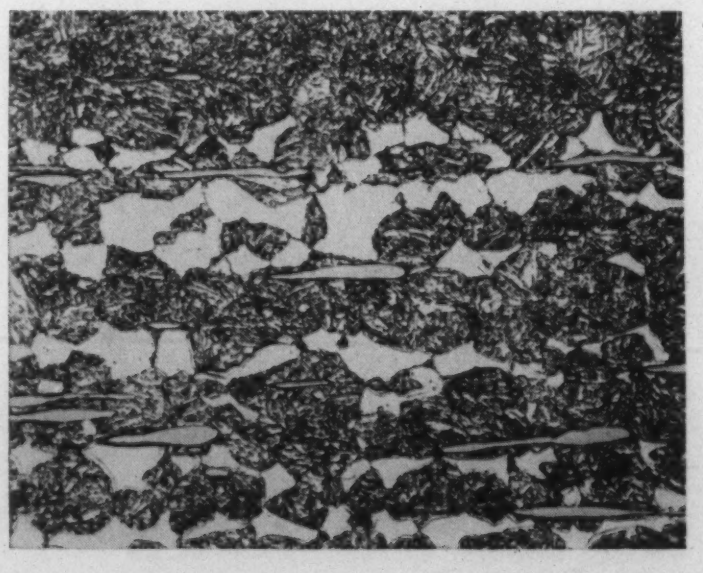


Fig. 31. Structure of hardened 12 per cent Cr. free-cutting stainless steel. Note that elongated gray sulphide particles are only slightly attacked by etching reagent. Matrix is martensite and white areas ferrite. Hardness 375 Brinell. Etchant: 10 per cent HCl in alcohol, electrolytic. Mag. 200X.

Fig. 32. Structure of cast 12 per cent Cr free-cutting stainless steel. Note that sulphide particles are globular in form. At rolling and forging temperatures they are plastic and tend to elongate in direction of work. Dark areas, martensite; white areas, ferrite. Hardness 375 Brinell. Etchant: 10% HCl in alcohol, electrolytic. Mag. 200X.

Stainless Steels–III

by STANLEY P. WATKINS

Manager, Development Division,
Rustless Iron and Steel Corp.
Baltimore, Md.

formation, and exists at all temperatures as ferrite. Also, it will be seen, as the carbon increases, with chromium fairly constant, the capacity to harden increases, due to the effect of carbon to produce larger amounts of austenite, which subsequently breaks down into the hard constituent, martensite.

When the commercial stainless steels, with chromium ranging between 14 and 21 per cent and containing from 0.05 to 0.20 per cent C, are heated in the range of 1650 to 1950 deg. F., a portion of the alloy transforms to austenite and subsequently decomposes to martensite upon rapid cooling (Fig. 37). However, normally the larger portion of the alloy remains ferritic at all temperatures and undergoes only grain growth, accompanied by surface decarburization (Fig. 39) at elevated temperatures. From a commercial standpoint, this circumstance is of importance in connection with maintaining a fine grain size during the processing of this material. Grain size cannot be refined by heat treatment alone as is the case with ordinary carbon steels and to a limited extent the martensitic stainless steels. In order to maintain a fine grain size in the ferritic stainless steels, it is necessary to anneal at temperatures below their critical ranges following hot or cold working operations. Once a coarse grain has been formed, the structure can only be refined by severely cold working or hot working at a low temperature (1400-1600°F.) followed by annealing.

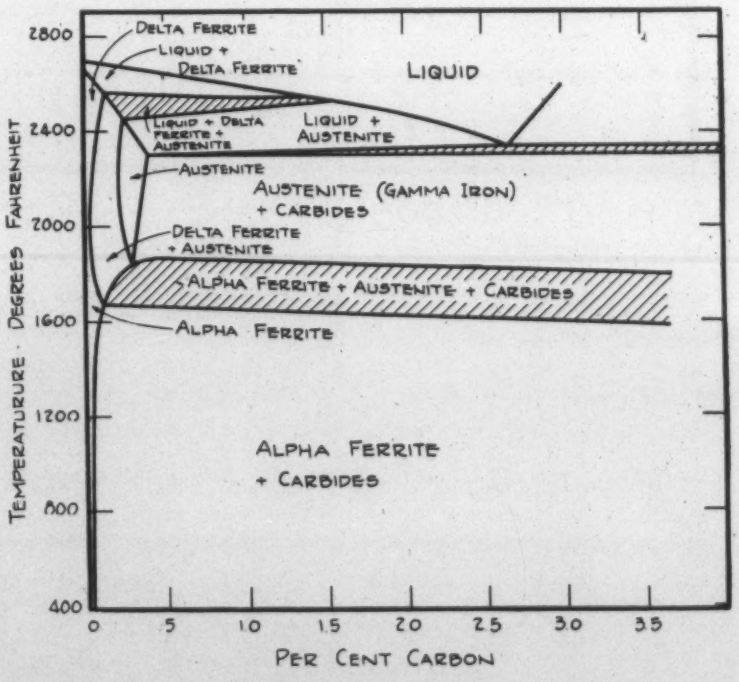
At hot forging and rolling temperatures, the structure of the 14 to 21 per cent Cr stainless steels consist of chromium-ferrite and austenite and in processing a laminated structure often results, such as shown by Fig. 40. Once such a structure is obtained, it cannot be wholly dissipated by heat treatment owing to the extremely slow rate at which carbon migrates in these alloys. Primarily, laminated structure is associated with the original dendritic condition existing in the ingot.

When the chromium is further raised to 23 to 30 per cent, the resulting alloy is wholly ferritic and the carbide particles present in the normal annealed structure (Fig. 42) remain unchanged up to about 2400 deg. F. where they are partly dissolved to form pools of austenite which can be retained by cooling fairly rapidly. Owing to the ability of chromium-ferrite to dissolve only about 0.02 per cent C, any amount in excess of this in these alloys must exist as free carbides and the structure will consist of carbides in a chromium-ferrite matrix. Since the carbides are only dissolved at extremely high temperatures, these stainless steels undergo no transformation at temperatures ordinarily used for hardening the stainless steels and for all practical purposes are non-hardenable. The amount of austenite formed at high temperatures is not sufficient to effect an increase in hardness. It follows then that the principal effect of heating these stainless steels to successively higher temperatures results in increase in grain size and coalescing of carbide particles.

Grain Growth in High Chromium Steels

The stainless steels with about 28 per cent Cr are particularly susceptible to grain growth at elevated

Fig. 33. Diagram of the 18 per cent Cr stainless steels with varying carbon content. (Book of Stainless Steels)



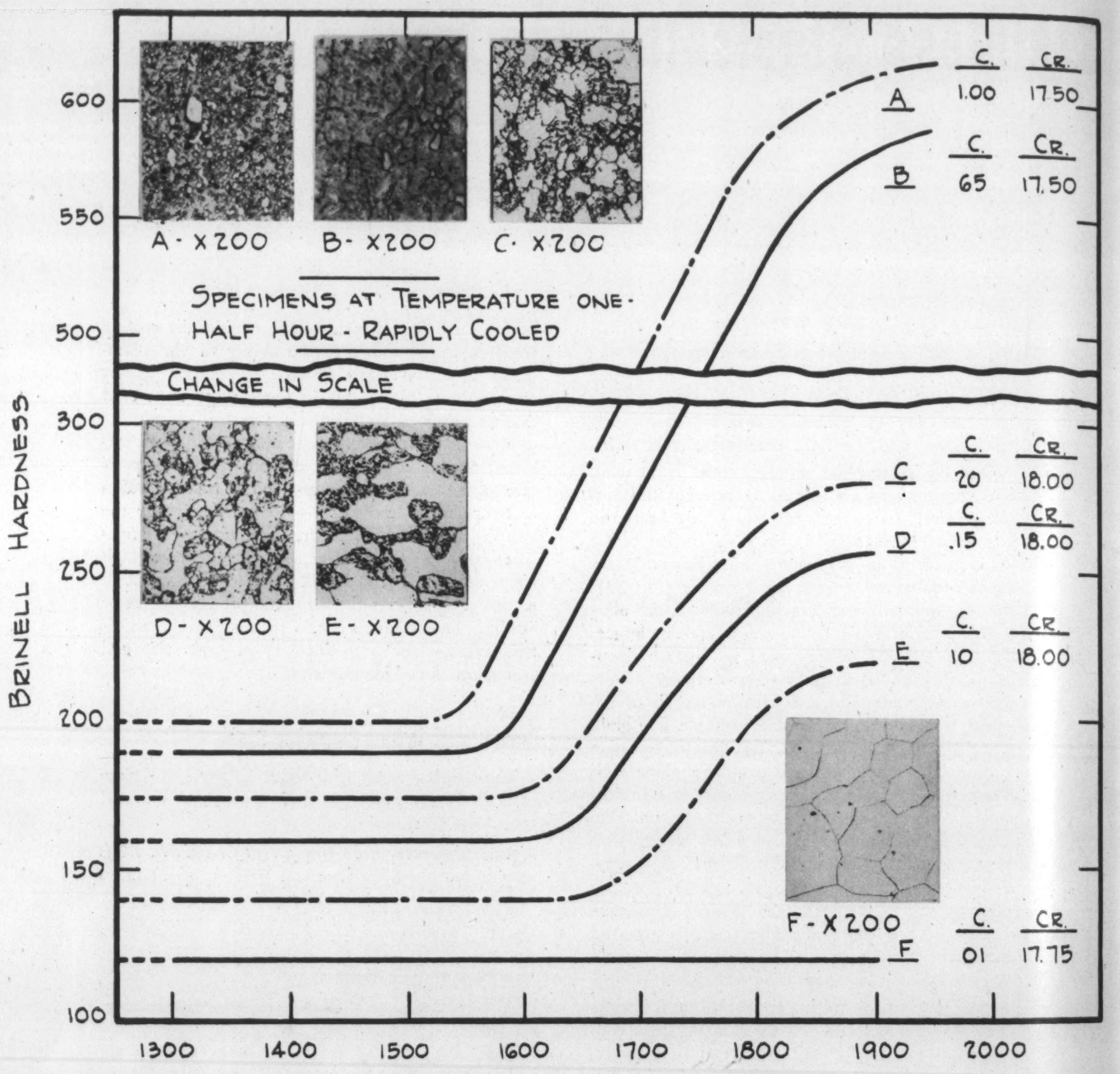
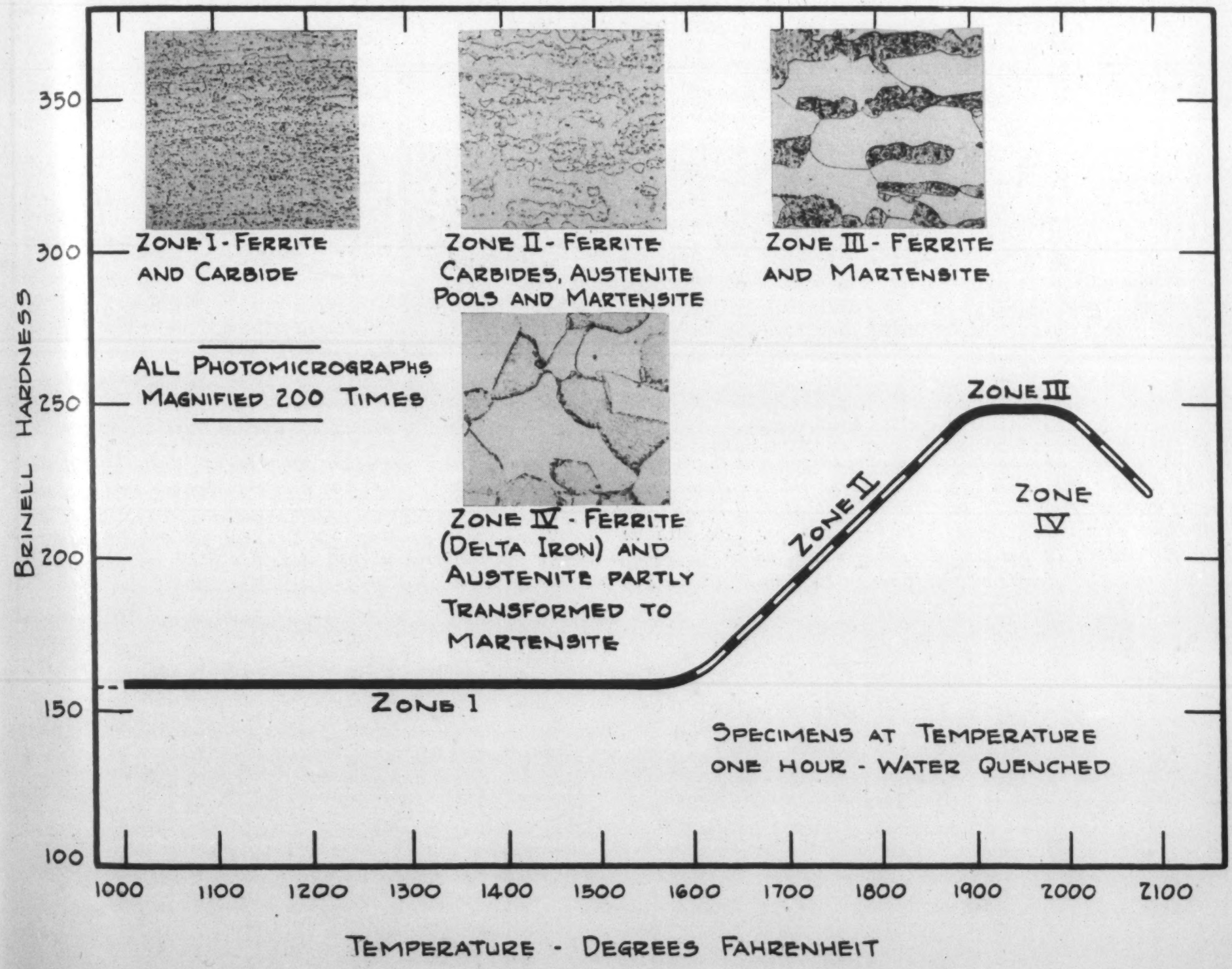


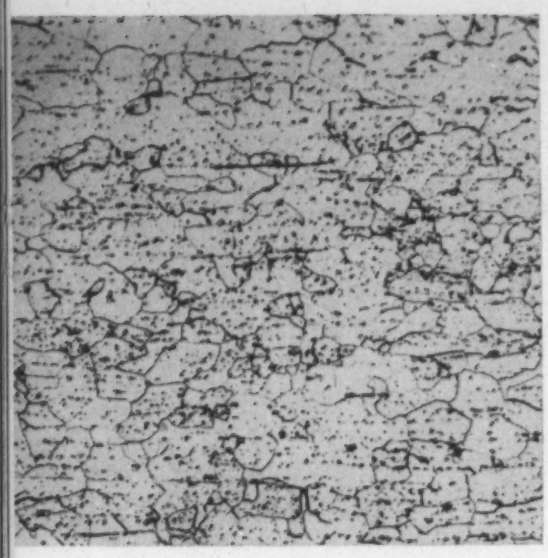
Fig. 34. Effect of carbon on the structure and hardenability of the 18 per cent Cr stainless steels.

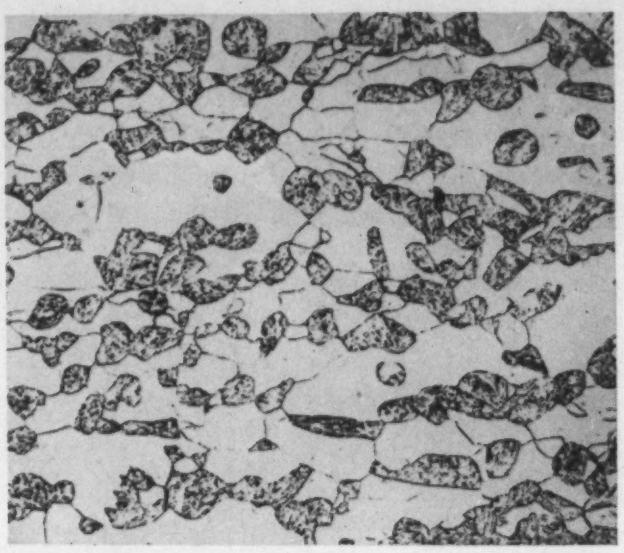
temperatures and this characteristic has served to restrict their use for many heat-resisting applications. Such growth is generally accompanied by a considerable decrease in ductility. The addition of approximately 0.15 per cent N to these alloys serves to minimize grain growth at elevated temperatures (Fig. 44) and most commercial alloys contain from 0.10 to 0.12 per cent of this element. However, it does not alter the microstructure as no difference is discernible between high and low nitrogen material in the annealed condition. On the other hand, when such alloys are quenched from high temperatures, the material with high nitrogen content will contain a higher proportion of austenite indicating that it acts similarly to carbon in promoting the formation of this phase.

A peculiar characteristic of the high chromium stainless steels is their tendency to suffer a great loss in ductility when slow cooled from the temperature range of 1100 to 1650 deg. F. Rapid cooling, such as water quenching, serves to avoid this condition. It has been shown that under some conditions, such as heating for long periods in the above range, a brittle constituent, designated as sigma phase, forms

Fig. 35. Effect of heating on the structure and hardness of a 0.10 per cent C, 18 per cent Cr stainless steel.







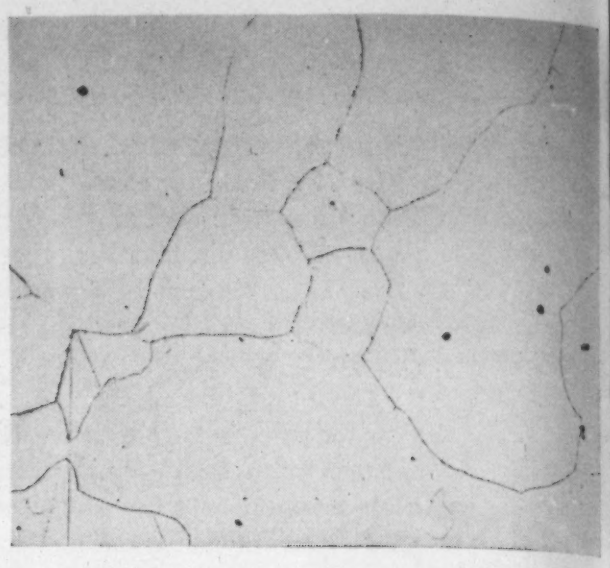
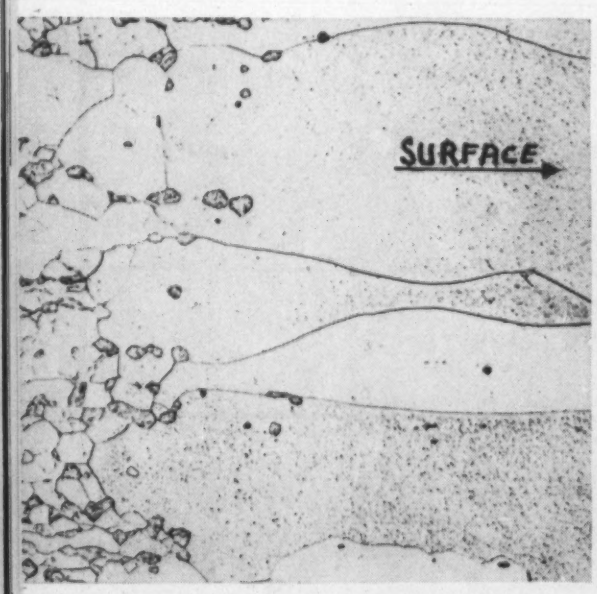
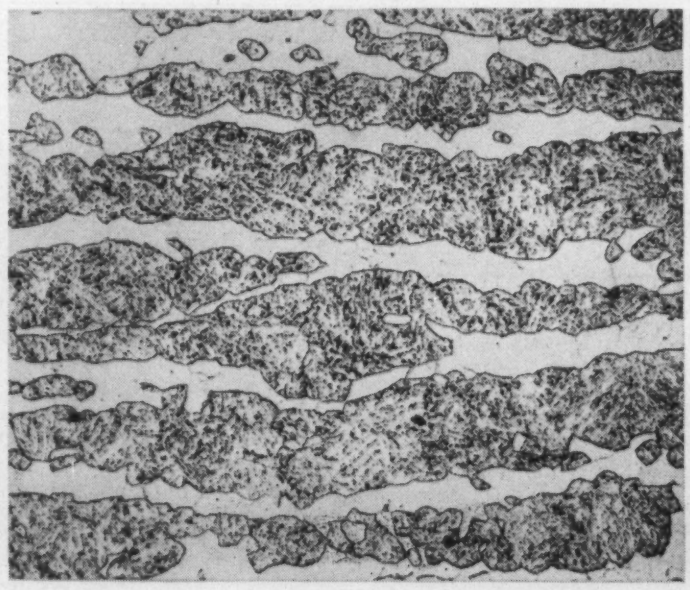


Fig. 36. Annealed structure of 0.10 per cent C, 18 per cent Cr stainless steel. Carbide particles in ferritic matrix. Hardness 170 Brinell. Etchant: 10 per cent HCl in alcohol, electrolytic. Mag. 200X. Fig. 37. (center) Structure of 0.10 per cent C, 18 per cent Cr stainless steel after quenching from 1900 deg. F. Dark areas are martensite in ferritic matrix. Hardness 255 Brinell. Etchant: 10 per cent HCl in alcohol, electrolytic. Mag. 200X. Fig. 38 (right) Structure of 0.01 per cent C, 18 per cent Cr stainless steel after quenching from 1900 deg. F. No austenite is formed in this alloy on heating, due to low carbon content; consequently, no hardening occurs on quenching: It remains ferritic at all temperatures. Hardness Rockwell "B" 67. Etchant: 10 per cent HCl in alcohol, electrolytic. Mag. 200X.





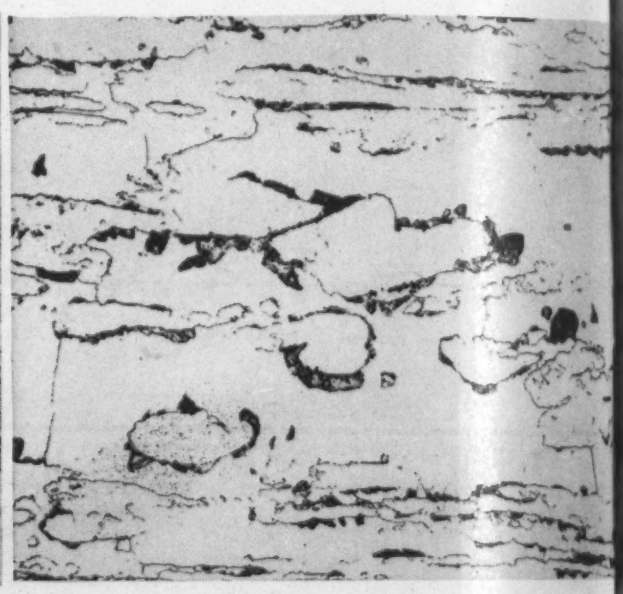
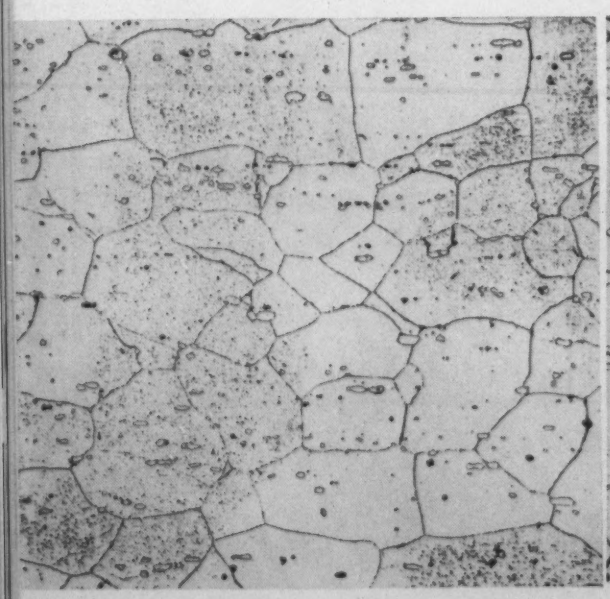


Fig. 39. Structure adjacent to surface of 0.10 per cent C, 18 per cent Cr stainless steel treated at 2000 deg. F. under conditions favoring decarburization. Etchant: 10 per cent HCl in alcohol, electrolytic. Mag. 200X. Fig. 40. (center) Showing laminated structure of 0.10 per cent C, 18 per cent Cr stainless steel resulting from hot working operations. Dark areas, martensite; white areas, ferrite. Hardness 255 Brinell. Etchant: 10 per cent HCl in alcohol, electrolytic. Mag. 500X. Fig. 41 (right) Structure of 0.10 per cent C, 18 per cent Cr stainless steel which has been hardened and tempered at 700 deg. F. Black areas are troostite in ferrite matrix. Hardness 200 Brinell. Etchant: 10 per cent HCl in alcohol, electrolytic. Mag. 200X.



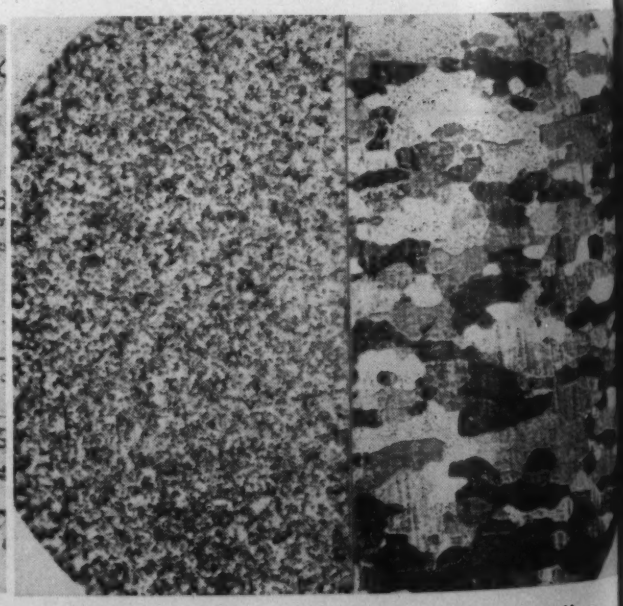
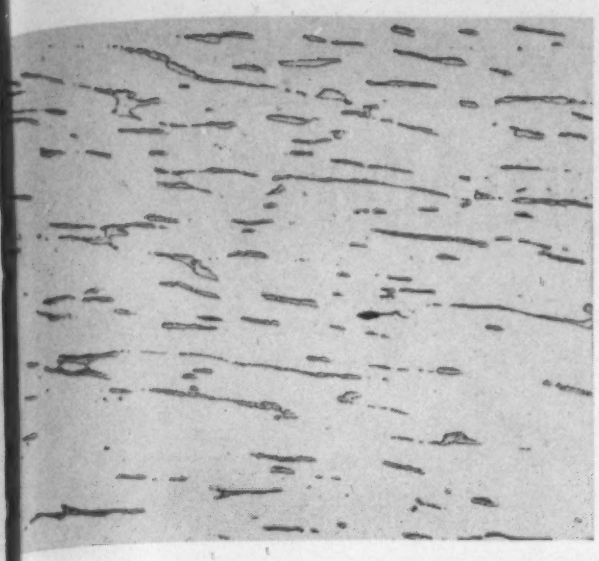
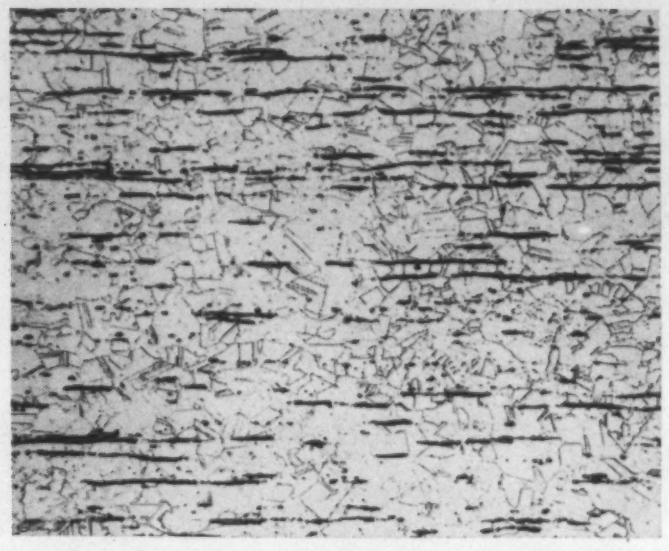


Fig. 42. Annealed structure of 0.20 per cent C, 27 per cent Cr stainless steel. Carbides in ferrite matrix. Hardness 170 Brinell. Etchant: 10 per cent HCl in alcohol, electrolytic. Mag. 100X. Fig. 43. (center) Structure of 0.20 per cent C, 27 per cent Cr stainless steel after exposure to 2000 deg. F. for six hours and cooled rapidly. Only effect of high temperature is to coarsen grain and cause coalescing of carbides. Hardness 180 Brinell. Etchant: 10 per cent HCl in alcohol, electrolytic. Mag. 100X. Fig. 44. (right) Illustrating effect of nitrogen on inhibiting grain growth in 0.15 per cent C, 28 per cent Cr stainless steel. Sample on left contained 0.238 per cent N, one on right 0.018 per cent N. Both samples exposed to 2300 deg. F. for one week. Etchant: 50 per cent HCl in water. Mag. 8X.





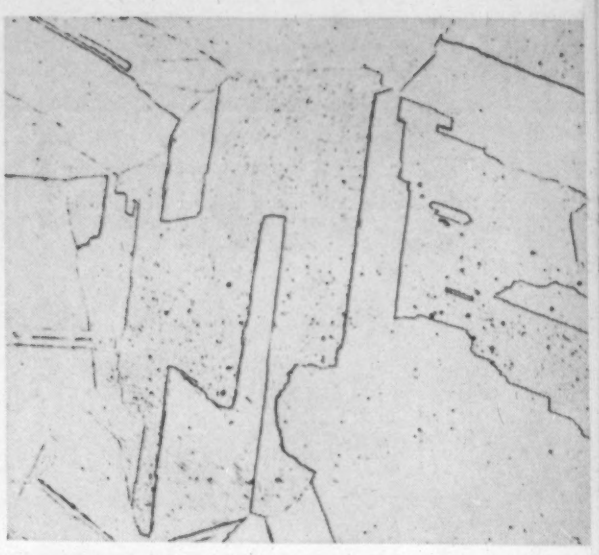


Fig. 45. Illustrating appearance of delta phase in low carbon 18 and 8 stainless steel. Alloy is slightly magnetic. Lightly etched in aqua regia reagent. Mag. 200X. Fig. 46. Delta phase in 18 and 8 is not as resistant to etching reagents as austenite matrix. Black areas delta phase wihch has been heavily attacked in etching to develop grain boundaries in austenite. Etchant: Aqua regia. Mag. 100X. Fig. 47. Annealed structure of 18 and 8 stainless steel. Uniformly austenitic with frequent trimming of crystals. Alloy is non-magnetic. Hardness 140 Brinell. Etchant: Aqua regia. Mag. 500X.

in these alloys and their low ductility after such a treatment is attributed to the action of this constituent.

As previously stated, the bulk of stainless steel production is in the austenitic (chromium-nickel) grades, and at first glance the metallography of these alloys appears quite simple since normally they consist of only one phase, austenite or gamma iron. However, a study of the constitutional diagram (Fig. 13) of the well known 18 and 8 stainless steel indicates the occurrence of certain reactions on heating and cooling which are decidedly not of a simple nature.

As previously shown, the addition of 18 per cent Cr to carbon-free iron permits chromium-ferrite to exist at all temperatures. However, if above about 4 per cent Ni is added to such alloys, the structure is wholly austenitic when water quenched from about 1800 deg. F. Although this small amount of nickel, in combination with 18 per cent Cr serves to produce a fully austenitic structure, the occurrence of this phase is restricted to a rather narrow range. In practice the nickel is maintained at about 8 per cent, which results in the well known "18 and 8" grade of stainless steel. The truly predominating phase in this alloy is austenite or gamma solid solution. However, if the ratio of chromium to nickel is changed or the carbon reduced to extremely low limits, some delta iron may be observed in annealed material. (Fig. 45). In these alloys, chromium, which favors the formation of chromium-ferrite (alpha or delta iron), is in opposition to nickel and carbon which promotes the formation and preservation of austenite (gamma iron). Therefore, the structure of these stainless steels depends primarily upon the proportion and ratio of these alloying elements.

Hardening the Austenitic Steels

The austenitic stainless steels cannot be hardened by any form of heat treatment; in fact, quenching from the range of 1850 to 2000 deg. F. which would harden the martensitic grades, merely softens them and this treatment is used to obtain chromium in solid solution, which places them in the best condition to resist corrosion. The microstructure produced by this "annealing" operation consists of polyhedral grains of austenite with narrow grain boundaries, similar to all solid solutions. A distinctive characteristic of the austenitic stainless steel is the frequent twinning of crystals (Fig. 47).

For all practical purposes, the austenitic stainless steels are considered to be in a stable condition, but from a true physicochemical standpoint, they are not in a state of equilibrium since under certain conditions, such as when cold worked or heated in the range of 900 to 1650 deg. F., they exhibit reaction characteristics similar to the martensitic stainless steels; namely, the transformation of austenite to chromium-ferrite and carbides. *(To be Concluded)*

Copper - Nickel - Zirconium - Aluminum Alloys

BY ERNEST F. NIPPES

Instructor in Metallurgical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y.

There is keen interest in the general subject of precipitation hardening. This article supplies added data in this field. The author finds that both aluminum and zirconium are very effective as hardeners in alloys of copper and nickel where the ratio is 3 to 1 and 1 to 1. For other copper:nickel ratios further investigation is still to be done. The hardening agent in these alloys may be a compound of aluminum and zirconium containing about 70 per cent Al.—The Editors.

TABLE I.—Al-Zr-Cu-Ni Alloys, Cu-Ni Ratio of 1 to 1

Alloy No.	Chemical analysis	Metallographic appearance after solid solution heat treatment	Heat treatment for highest hardness deg. C.	Vickers Pyramid Num. Solid Solution	Vickers Pyramid Num. Aged
18	49.1 Cu 49.1 Ni 1.87 Zr	Solid solution 2% "excess" phase	10 hrs. 600	118	149
19	48.3 Cu 48.3 Ni 3.32 Zr	Solid solution 5% "excess" phase	10 hrs. 500	123	165
24	48.5 Cu 48.5 Ni 2.02 Zr 0.86 Al	Solid solution 2% "excess" phase	42 hrs. 600	127	171
25	47.9 Cu 47.9 Ni 2.10 Zr 2.05 Al	Solid solution 5% "excess" phase	20 hrs. 500	125	225
28	49.4 Cu 49.4 Ni 1.11 Al	Solid solution	24 hrs. 600	78	92
29	48.9 Cu 48.9 Ni 2.14 Al	Solid solution	48 hrs. 500	92	118
30	48.9 Cu 48.9 Ni 0.98 Zr 1.21 Al	Solid solution	41 hrs. 500	99	179
31	49.1 Cu 49.1 Ni 0.93 Zr 0.78 Al	Solid solution	24 hrs. 600	111	154
32	48.8 Cu 48.8 Ni 1.54 Zr 0.90 Al	Solid solution 0.1% "excess" phase	41 hrs. 500	117	186
33	49.0 Cu 49.0 Ni 1.39 Zr 0.69 Al	Solid solution 0.2% "excess" phase	41 hrs. 500	124	170
34	48.9 Cu 48.9 Ni 1.63 Zr 0.58 Al	Solid solution 0.3% "excess" phase	24 hrs. 600	123	162
37	48.5 Cu 48.5 Ni 2.99 Al	Solid solution	12 hrs. 600	100	120
38	48.0 Cu 48.0 Ni 0.61 Zr 3.31 Al	Solid solution	48 hrs. 600	113	262
39	48.2 Cu 48.2 Ni 1.18 Zr 2.35 Al	Solid solution	48 hrs. 600	133	278
40	48.6 Cu 48.6 Ni 0.81 Zr 2.03 Al	Solid solution	45 hrs. 500	125	191
41	48.5 Cu 48.5 Ni 0.61 Zr 2.44 Al	Solid solution	48 hrs. 600	124	238
42	48.4 Cu 48.4 Ni 1.53 Zr 1.62 Al	Solid solution 0.1% "excess" phase	45 hrs. 500	133	205
43	48.7 Cu 48.7 Ni 0.73 Zr 1.84 Al	Solid solution	45 hrs. 500	132	179
44	48.4 Cu 48.4 Ni 1.82 Zr 1.47 Al	Solid solution 0.4% "excess" phase	24 hrs. 500	133	198
50	48.0 Cu 48.0 Ni 0.98 Zr 3.08 Al	Solid solution	22 hrs. 600	123	285

IT HAS BEEN ONLY RECENTLY that copper-zirconium alloys have been reported as precipitation hardenable. In a patent, Hensel and Larsen[1] described a 1 per cent zirconium-copper alloy which upon aging for 8 hrs. at 450 deg C. shows an increase of Rockwell "B" hardness from 10 to 59. Comstock and Bannon[2] further investigated the copper-zirconium alloys confirming the results of Hensel and Larsen.

A great number of modified copper-zirconium alloys have been described. In so far as this investigation was concerned, some of the more important modified alloys are briefly described by Hensel and Larsen[3] in their patent on copper-zirconium alloyed with iron, cobalt or nickel.

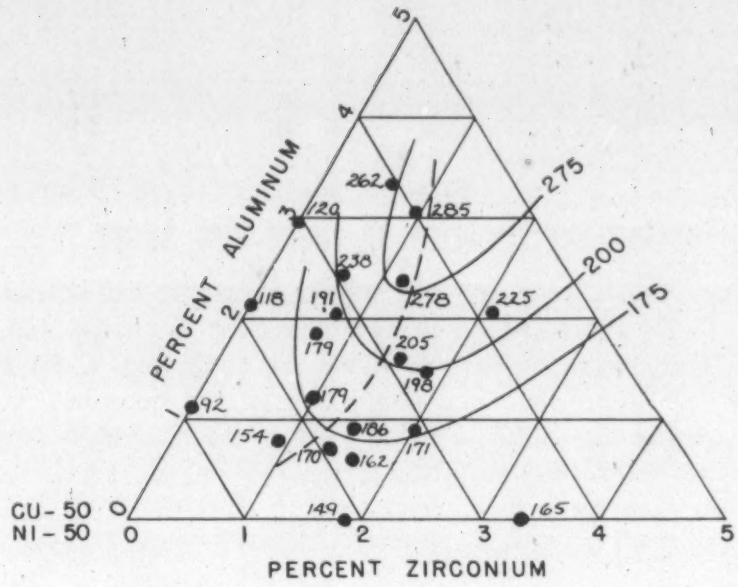
Roberts[4] in an unpublished investigation described an alloy of (composition determined by computation of alloy additions), 8 per cent Ni, 5 per cent Zr in copper with 2.5 per cent Al as an impurity. This alloy, when aged 1 hr. at 500 deg. C. and then reduced 50 per cent by cold work increased in strength from 60,000 to 186,000 lbs. per sq. in.

Plan of the Investigation

This investigation was limited to the effect of zirconium and both zirconium and aluminum, as

TABLE II.—Al-Zr-Cu-Ni Alloys, Cu-Ni Ratio of 3 to 1

Alloy No.	Chemical analysis	Metallographic appearance after solid solution heat treatment	Heat treatment for highest hardness deg. C.	Vickers Pyramid Num. Solid Solution	Vickers Pyramid Num. Aged
16	73.5 Cu 24.5 Ni 1.92 Zr	Solid solution 2% "excess" phase	10 hrs. 500	88	167
17	72.6 Cu 24.2 Ni 3.21 Zr	Solid solution 5% "excess" phase	10 hrs. 500	92	170
35	72.4 Cu 24.1 Ni 1.98 Zr 1.52 Al	Solid solution 1% "excess" phase	41 hrs. 500	124	254
36	73.3 Cu 24.4 Ni 0.83 Zr 1.41 Al	Solid solution 0.1% "excess" phase	41 hrs. 500	100	191
45	73.5 Cu 24.5 Ni 0.85 Zr 1.20 Al	Solid solution	22 hrs. 600	88	170
46	72.2 Cu 24.1 Ni 1.15 Zr 2.60 Al	Solid solution	10 hrs. 600	118	274
47	71.8 Cu 23.0 Ni 2.02 Zr 2.21 Al	Solid solution 1% "excess" phase	50 hrs. 500 Alloy barely cold forgeable	120	281
48	71.8 Cu 23.9 Ni 0.90 Zr 3.39 Al	Solid solution 0.5% "excess" phase	50 hrs. 500 Alloy barely cold forgeable	166	306
49	71.6 Cu 23.9 Ni 1.52 Zr 3.02 Al	Solid solution 2% "excess" phase	Alloy not cold forgeable		
51	73.4 Cu 24.5 Ni 1.30 Zr 1.79 Al	Solid solution 0.2% "excess" phase	48 hrs. 500	133	250



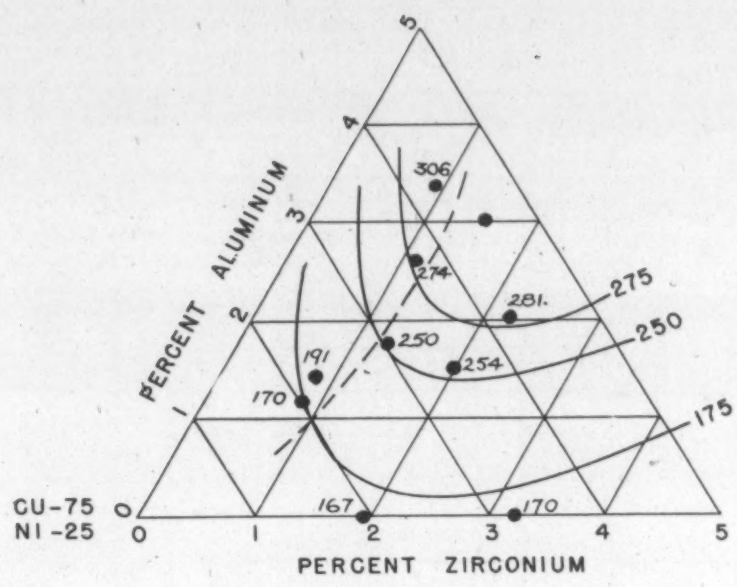


Fig. 1. (left) Iso-hardness charts for aluminum-zirconium-copper nickel with a copper-nickel ratio of one to one. Dots represent alloys, the numbers over each dot are the highest Vickers Pyramid Numeral attained during aging by this alloy. Solid curves are iso-hardness curves along which equal Vickers Pyramid Numerals occur after aging. The dashed curve represents the approximate solid solution curve at 1050 deg. C., as was determined from the metallographic appearance of samples quenched from this temperature.

Fig. 2. (right) Iso-hardness chart for aluminum-zirconium-copper nickel alloys with a copper-nickel ratio of three to one. Same explanations as for Fig. 1.

hardeners using copper-nickel ratios of three to one and one to one. The two best alloys of aluminum-zirconium additions to these copper-nickel ratios were further investigated for possible industrial applications.

Melting Procedure

Copper-nickel-zirconium-aluminum alloys were made using a commercial copper-zirconium alloy as the source of zirconium. The chemical analysis of this master alloy was: Cu 74.13, Zr 25.62, Ti 0.12, and Fe 0.13 per cent.

These alloys were melted in a 35 kva. Ajax Northrup high frequency furnace using alundum lined crucibles. Melts were of approximately 400 gram weight. They were carried out as follows: Electrolytic copper and nickel were melted down under a bottle glass slag; after the melt had picked up sufficient superheat, the glass slag was drawn and the melt deoxidized with silicon until it "quietcd"; and was desulphurized and still further deoxidized by means of calcium (0.2% of total weight of melt); then the copper-zirconium alloy was added piece by piece, a nickel stirring rod was used to hold the pieces under the surface of the bath until solution occurred; aluminum was added; the bath was deslagged; the final step was the casting of the alloy in preheated 3/8-in. round three-finger molds.

The recovery of zirconium, as determined by

TABLE III.—Effect of Cold Work on Alloy No. 39 0.0910 in. wire—solid solution condition

Per cent cold reduction	Vickers pyramid numeral	Tensile strength lbs. per sq. in.	Per cent elongation in 2 in.	Resistivity, ohms per cir. mil ft.
0.0	136	89,500	30.5	336
13.0	220	106,000	11.0	340
37.5	249	127,800	6.0	341
52.5	—	137,800	5.0	345
	Effect of Cold Work on Alloy No. 46 0.0910 in. wire—solid solution condition			
0.0	136	77.700	24.5	237
15.0	205	100,400	10.0	238
27.2	217	110,500	6.0	239
37.5	220	115,200	5.0	240

TABLE IV.—Effect of Aging on Alloy No. 39 0.0910 in. wire—solid solution condition, no cold work

Aging conditions	Vickers pyramid numeral	Tensile strength, lbs. per sq. in.	Per cent elongation in 2 in.	Resistivity, ohms per cir. mil ft.
0 hrs.	136	89,500	30.5	336
2 hrs.—500°C.	168	116,200	28.5	345
4 hrs.—500°C.	213	120,200	26.0	345
8 hrs.—500°C.	240	127,000	23.5	334
2 hrs.—550°C.	254	116,000	24.0	333
4 hrs.—550°C.	240	124,100	23.0	326
8 hrs.—550°C.	265	125,600	20.0	316
16 hrs.—550°C.	274	134,400	18.0	310
2 hrs.—600°C.	240	113,900	24.0	310
4 hrs.—600°C.	266	140,200	18.0	302
8 hrs.—600°C.	279	140,200	17.0	291
16 hrs.—600°C.	297	129,000	15.0	286

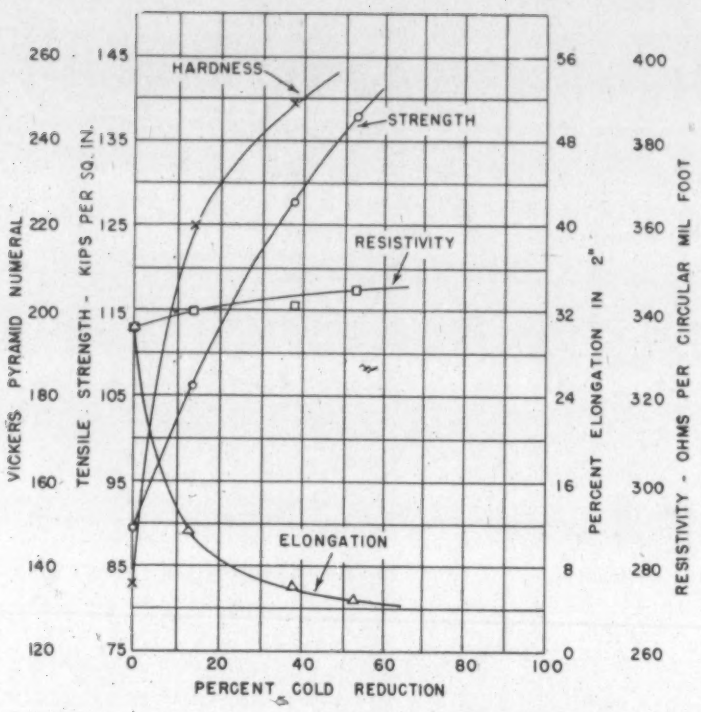


Fig. 3. Effect of cold work on Alloy No. 39.

chemical analysis, varied from 75 to 85 per cent, while the aluminum recovery varied from 85 to 95 per cent.

Heat Treatment

The alloys as cast were cold rolled to approximately ¼-in. sq. rods and were homogenized for 6 hrs. at 1050 deg. C. in a dry hydrogen atmosphere and were then water quenched to retain the solid solution.

After polishing, etching, and metallographic examination, the samples were aged at 500 and 600 deg. C. in an atmosphere of dry city gas. A typical aging series would include 1, 2, 6, 12, 24, and 48 hrs. at temperature. The progress of the aging was followed by taking Vickers pyramid numerals using a 10-kg. load. Each value recorded was the average of at least three readings.

The results of these studies of aluminum and zirconium additions to copper-nickel ratio of one to one are summarized in Table I. In order to visualize these results more easily, they have been plotted on a 3-coordinate graph in Fig. 1. Table II and Fig. 2 show the results of aluminum and zirconium additions to a copper-nickel ratio of three to one.

It was decided, after reviewing these results, to further investigate the best aluminum-zirconium-copper-nickel alloys: One, having a copper-nickel ratio of three to one, the other a ratio of one to one.

The alloys chosen were just within the solid solution curve at 1050 deg. C. and exhibited excellent increases of hardness upon aging. The two alloys chosen were:

	No. 39	No. 46
Al	2.35	2.60
Zr	1.18	1.15
Cu	48.2	72.2
Ni	48.2	24.1

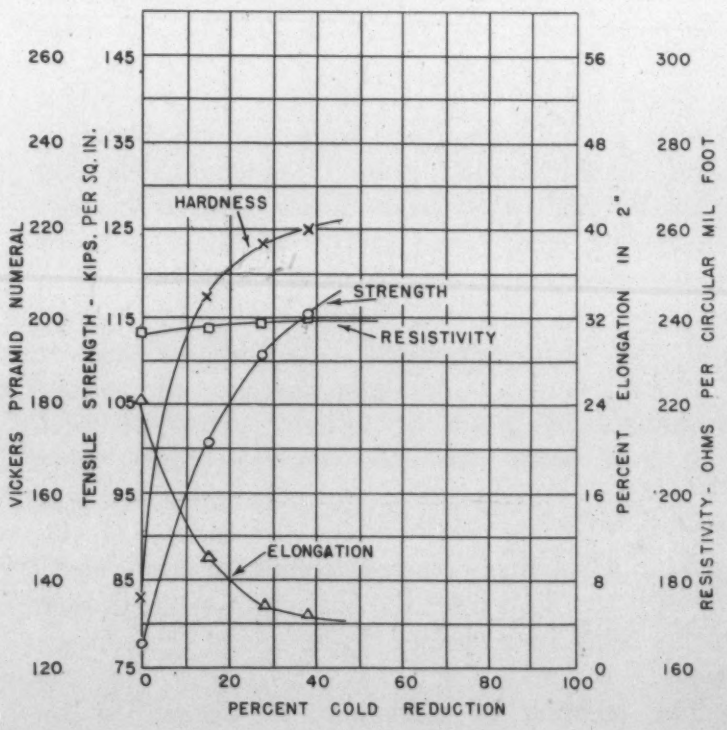
Further Investigation on These Two Alloys

Alloys Nos. 39 and 46 were cold rolled as cast from ⅜ in. round to approximately ¼ in. sq. rod. They were heated for 6 hrs. at 1050 deg. C. in a dry hydrogen atmosphere and water quenched to retain the solid solution. After approximately 65 per cent cold reduction (from ¼ in. rod to 0.150 in. sq. rod) they were given a solid solution heat

TABLE V.—Effect of Aging on Alloy No. 46 0.0910 in. wire—solid solution condition, no cold work

Aging conditions deg. C.	Vickers pyramid numeral	Tensile strength, lbs. per sq. in.	Per cent elongation in 2 in.	Resistivity, ohms per cir. mil ft.
0 hrs.	136	77,700	24.5	237
2 hrs.—500	242	111,800	18.5	204
4 hrs.—500	260	128,800	13.0	198
8 hrs.—500	292	131,100	11.5	197
16 hrs.—500	300	132,200	10.5	196
2 hrs.—550	276	130,900	14.5	210
4 hrs.—550	270	129,200	12.5	202
8 hrs.—550	285	131,300	10.0	185
16 hrs.—550	279	140,200	8.5	186
2 hrs.—600	285	137,500	11.5	199
4 hrs.—600	294	138,500	9.0	194
8 hrs.—600	297	143,500	8.0	184
16 hrs.—600	289	132,200	7.0	185

Fig. 4. Effect of cold work on Alloy No. 46.



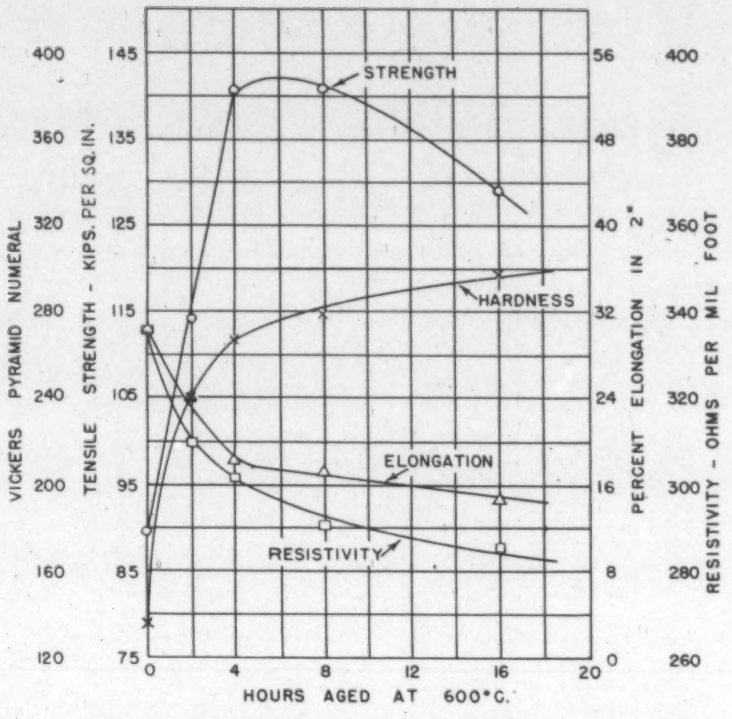


Fig. 5. Effect of aging Alloy No. 39 at 600 deg. C. Solid solution condition, no cold work.

treatment at 1050 deg. C. for 20 min. Further cold rolling and finally wire drawing gave a wire 0.0910 in. in dia. and these wires were given a solid solution heat treatment at 1050 deg. C. for 15 min.

The effect of cold work on both alloys was investigated. The following properties were studied: tensile strength, Vickers pyramid numeral, percentage elongation in 2 in. and electrical resistivity. Tensile tests were performed on a Baldwin-Southwark 60,000-lb. hydraulic testing machine, readings being taken on the 0 to 5000-lb. scale, using Templin grips with jaws intended for wire testing, at the same time the elongation in 2 in. (bteween 2 gauge marks lightly scribed on the wires) was measured. The Vickers pyramid numeral, using a 10-kg. load, was taken on a smoothed longitudinal section of the wire. Electrical resistivity measurements were performed on a Kelvin Double Bridge. The results on these tests are shown in Tables III and graphically in Figs. 4 and 5.

Two sets of each alloy, one set in the form of wire 0.0910 in. solid solution condition with no cold work; and the other, in the form of wire 0.020 in. solid solution reduced 37.5 per cent by wire drawing from 0.0910 to 0.0720 in. were aged at 500, 550, and 600 deg. C. in a dry city gas atmosphere for 2, 4, 8 and 16 hrs. Tensile strength, Vickers pyramid numeral, percent elongation in 2 in. and electrical resistivity were the properties investigated, using the technique as described above. The results of these tests are shown in Tables IV to VII and the best aging conditions are shown graphically in Figs. 6 to 9.

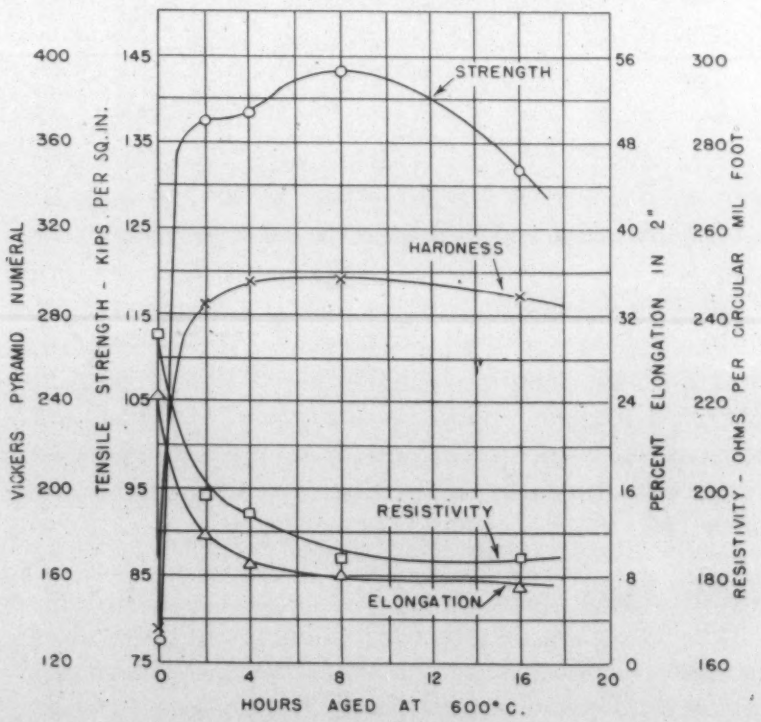
TABLE VI.—Effect of Aging Alloy No. 39 0.0720 in. wire—solid solution, cold worked 37.5 per cent

Aging conditions deg. C.	Vickers pyramid numeral	Tensile strength, lbs. per sq. in.	Per cent elongation in 2 in.	Resistivity, ohms per cir. mil ft.
0 hrs.	249	127,800	6.0	341
2 hrs.—500	312	159,500	7.0	325
4 hrs.—500	319	162,600	7.0	322
8 hrs.—500	345	160,000	4.0	317
16 hrs.—500	363	171,100	4.5	310
2 hrs.—550	319	146,600	7.0	319
4 hrs.—550	327	149,000	6.0	312
8 hrs.—550	360	170,900	3.5	290
16 hrs.—550	355	167,000	3.5	283
2 hrs.—600	333	161,200	8.5	313
4 hrs.—600	351	162,000	8.0	297
8 hrs.—600	340	164,900	7.0	290
16 hrs.—600	339	164,900	6.5	285

TABLE VII.—Effect of Aging on Alloy No. 46 0.0720 in. wire—solid solution, cold worked 37.5 per cent

Aging conditions deg. C.	Vickers pyramid numeral	Tensile strength, lbs. per sq. in.	Per cent elongation in 2 in.	Resistivity, ohms per cir. mil ft.
0 hrs	220	115,200	5.0	240
2 hrs.—500	327	151,700	10.0	193.5
4 hrs.—500	345	157,300	8.5	185
8 hrs.—500	364	157,800	6.0	178.5
16 hrs.—500	363	157,900	3.5	178
2 hrs.—550	330	157,500	7.5	186.5
4 hrs.—550	363	161,000	6.5	178
8 hrs.—550	342	158,500	5.0	179
16 hrs.—550	335	149,200	4.5	178.5
2 hrs.—600	336	158,300	6.5	188
4 hrs.—600	327	157,100	6.0	181.5
8 hrs.—600	317	153,600	5.5	177

Fig. 6. Effect of aging Alloy No. 46 at 600 deg. C. Solid solution condition, no cold work.



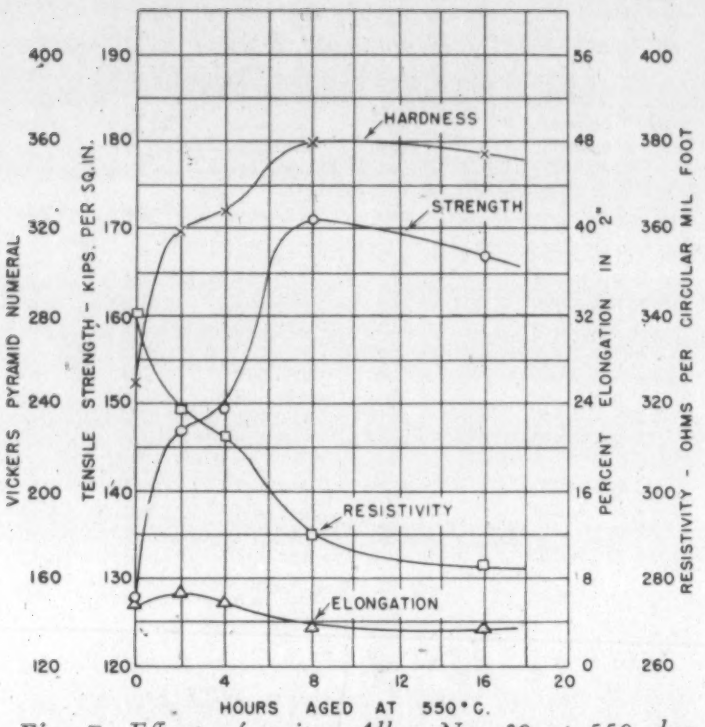


Fig. 7. Effect of aging Alloy No. 39 at 550 deg. C. Solid solution, cold worked 37.5 per cent.

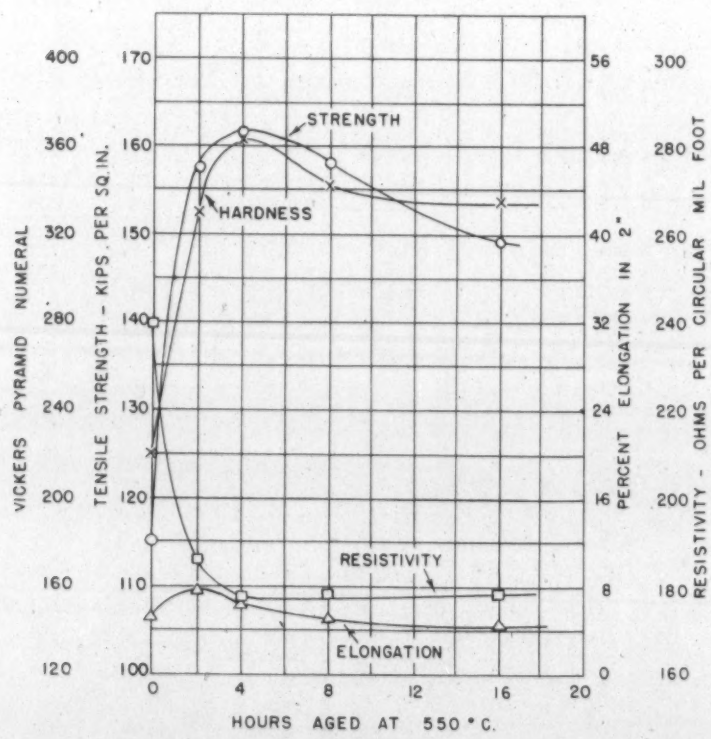


Fig. 8. Effect of aging Alloy No. 46 at 550 deg. C. Solid solution, cold worked 37.5 per cent.

Photomicrography

Photomicrographs were taken on a Zeiss Neophot at 100X, the samples being etched with 30 percent Marble's reagent. Photomicrographs of longitudinal sections of wires are exhibited in Fig. 10 for different conditions of alloy No. 39 and Fig. 11 for alloy No. 46.

Double Aging

The effect of double aging, that is, precipitation hardening followed by cold work and a second aging period, was investigated on both alloys. Alloy No. 39, when in the solid solution condition with no cold work, exhibited the best properties when aged 8 hrs. at 600 deg. C., likewise, alloy No. 46 when aged 8 hrs. at 600 deg. C. Both alloys, as aged (8 hrs. at 600 deg. C.) were reduced 47 percent by wire drawing and reaged for 2 hrs. and 4 hrs. at 550 deg. C. in a dry city gas atmosphere. The only properties investigated were tensile strength and per cent elongation in 2 in. The results of these tests are exhibited in Tables VIII and IX. No other treatments were investigated.

TABLE VIII.—Effect of Double Aging on Alloy No. 39

Condition	Tensile strength lbs. per sq. in.	Per cent elongation in 2 in.
Aged 8 hrs. at 600°C.	140,200	17.0
Aged 8 hrs. at 600°C., cold worked 47%	158,800	5.0
Aged 8 hrs. at 600°C., cold worked 47% reaged 2 hrs. 550°C.	195,600	3.5
Aged 8 hrs. at 600°C., cold worked 47% reaged 4 hrs. 550°C.	191,800	3.5

TABLE IX.—Effect of Double Aging on Alloy No. 46

Condition	Tensile strength lbs. per sq. in.	Per cent elongation in 2 in.
Aged 8 hrs. at 600°C.	143,500	8.0
Aged 8 hrs. at 600°C. cold worked 47%	156,300	3.0
Aged 8 hrs. at 600°C., cold worked 47% reaged 2 hrs. at 550°C.	169,200	4.0
Aged 8 hrs. at 600°C., cold worked 47% reaged 4 hrs. at 550°C.	181,800	3.5

TABLE X.—Summary of Effect of Cold Work

	Tensile strength lbs. per sq. in.	Per cent elongation in 2 in.
No. 39 solid solution, cold worked 37.5%, aged 8 hrs. at 550°C.	170,900	3.5
No. 39 solid solution, aged 8 hrs. at 600°C., cold worked 47%	158,800	5.0
No. 46 solid solution, cold worked 37.5%, aged 4 hrs. at 550°C.	161,000	6.5
No. 46 solid solution, cold worked 47% aged 8 hrs. at 600°C.,	156,300	3.0

Conclusions

It was found that aluminum and zirconium were very effective as hardeners in alloys where the ratio of copper-nickel was three to one and one to one. Investigations are underway to determine the effect

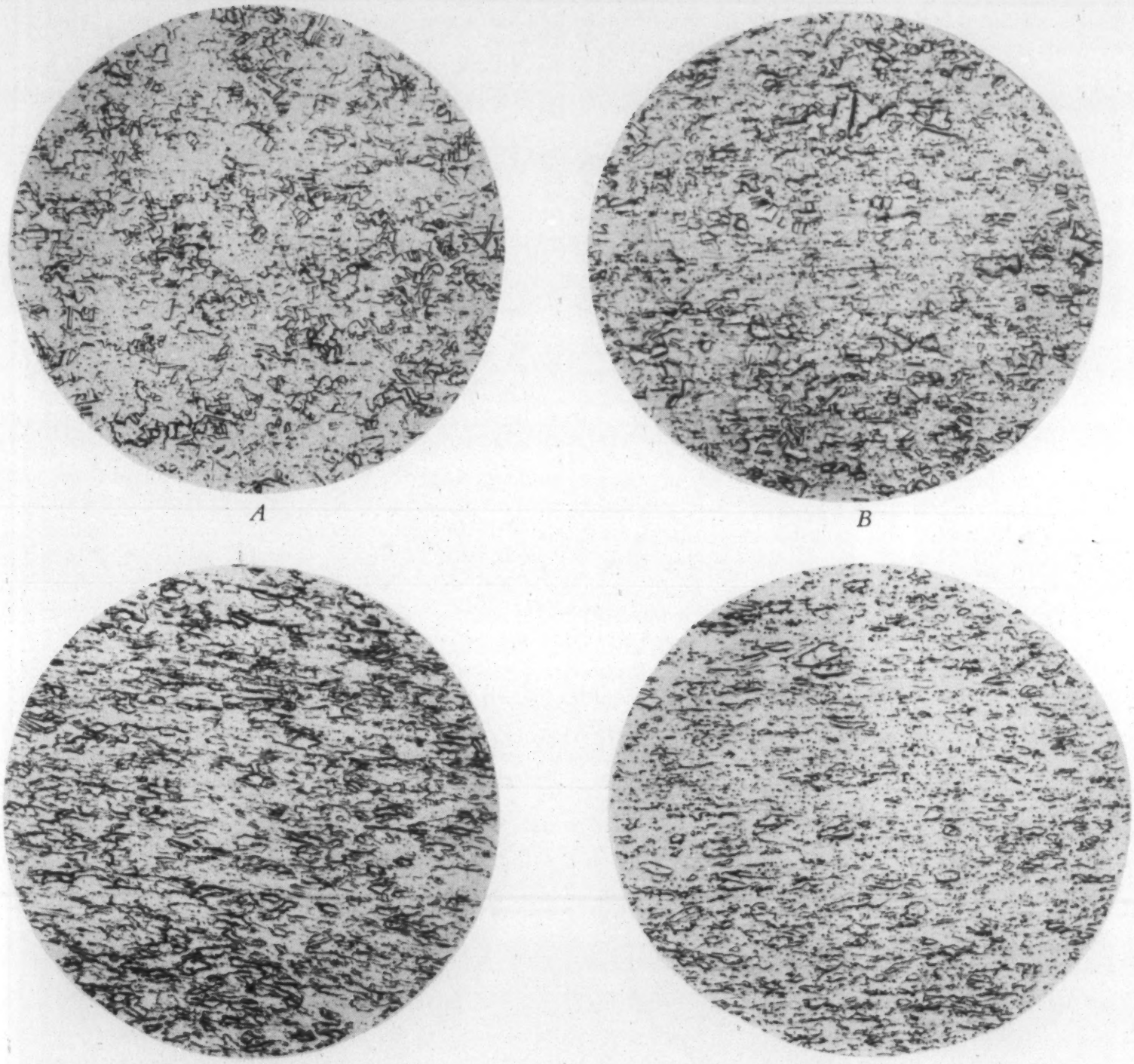


Fig. 9. Photomicrographs of longitudinal sections of wires of Alloy No. 39. 100X. A. Solid solution condition—as quenched from 1050 deg. C.; B. As aged—8 hrs. at 600 deg. C.; C. Solid solution, cold worked 37.5 per cent; D. Solid solution, cold worked 37.5 per cent and aged 8 hrs. at 550 deg. C.

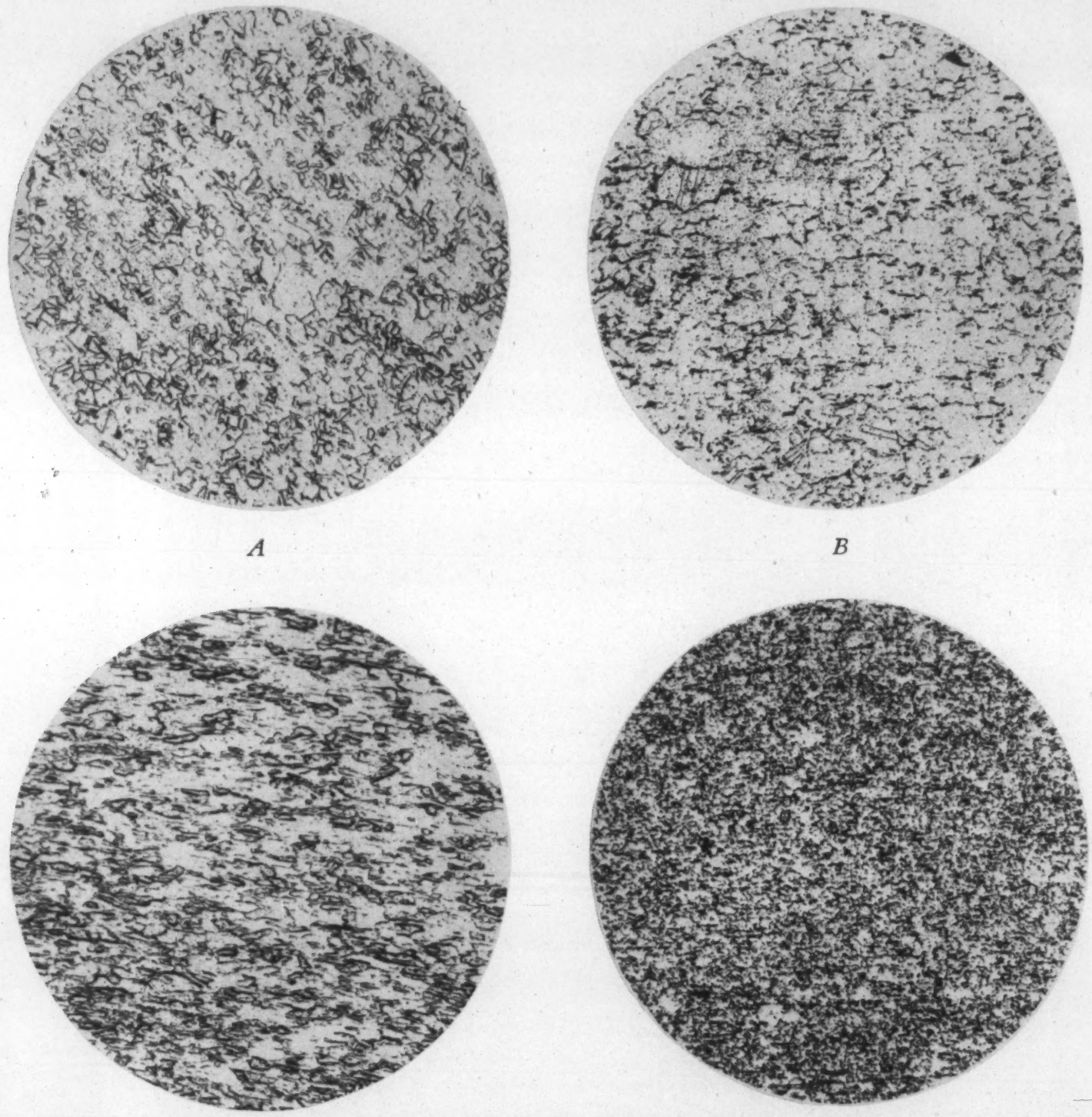
of aluminum and zirconium as hardeners on other copper-nickel ratios.

It is not certain what actually causes precipitation hardening in these alloys, but from the contours of the iso-hardness charts (Figs. 1 and 2) it can be seen that a compound of aluminum and zirconium, containing about 70 percent Al may be the cause. In order to definitely establish the compound, which is being precipitated and is causing the hardening, more investigation must be undertaken.

A summary of the best aging conditions for the two selected alloys with corresponding properties are shown in Table VI. Photomicrographs of all the conditions of Table VI are illustrated in Figs. 10 and 11. It is noticed in the aged condition that alloy No. 46 definitely shows a precipitated phase, whereas alloy No. 39 displays slightly broader grain boundaries. Alloy No. 46 exhibits complete recrystallization in the cold worked and aged condition, whereas alloy No. 39 shows only partial recrystallization.

Better properties were obtained by cold work followed by aging, rather than aging followed by cold work. This may be observed in Table X.

As would be expected, double aging, in this case precipitation hardening followed by cold work and a second aging period, gave even better properties than single aging. (Tables IV and V). They have



A *B*

C *D*

Fig. 10. Photomicrographs of longitudinal sections of wires of Alloy No. 46. 100X. A. Solid solution condition—as quenched from 1050 deg. C.; B. As aged 8 hrs. at 600 deg. C.; C. Solid solution, cold worked 37.5 per cent; D. Solid solution, cold worked 37.5 per cent and aged 4 hrs. at 550 deg. C.

the disadvantage, however, of requiring longer total time of aging.

Acknowledgments: The author wishes to express his appreciation of the assistance rendered by Dr. M. A. Hunter, head of the department of metallurgy, Rensselaer Polytechnic Institute, in suggesting this investigation and in offering valuable counsel during the study.

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(*Editorials—Continued from page 271*)

of raw material cost, fabrication expense, strength or corrosion resistance have clearly indicated metals to be preferable. In these pages and elsewhere, the design advantages of either metals or plastics have been cited for such products as housings of various types, automobile interior decor, radio cabinets, camera cases, business machine parts, bath room fixtures, household appliances, novelties—even some types of bearings, pulleys, gears and cams. But today, for such products as these, normal design considerations do not apply. In many cases, if the products are to be made at all, they will have to be redesigned for some material not in great defense demand; in others, obstinate insistence on the former metal or fabricating process will mean delays, production tie-ups—possibly the eventual stoppage of raw material supply anyway—and the loss of customer good-will. Better cheerfully to make the most of a situation that is certain to be worse before it gets better, and see if the design can't be modified to accommodate plastics and still yield a satisfactory product.

Producers of these metals also stand to benefit from a general program by non-armament design engineers to use plastics wherever possible. Some producers will lose no business whatever, since they now have or probably soon will have no extra metal to ship to non-essential industries, anyway; the others should welcome a trend that will ease their uncomfortable position, between the threat of priorities on one hand and the threats of purchasing agents on the other. For the first time in our personal history, we've heard in the last few weeks producer's *complaints* that for some materials there are just too many customers!

Indeed, the producers of these much-in-demand metals can assure for themselves not only the present good-will of all their customers (and the not-entirely-valueless gratitude of the American people) but a *permanent* position of commercial leadership by simultaneously doing two simple and straightforward things: First, actively and publicly *encourage* the immediate substitution of plastics for their materials wherever possible in non-defense products, even to the extent of giving technical assistance in the redesign of affected products and in the choice of suitable plastic; second, by every means available—representative's calls, direct mail and regular advertising—continually remind the temporarily-diverted customers of the producer's ultimate interest in their needs, of the normally realizable but now unavailable design advantages of the metals involved, and of the importance to the customer of re-employing these metals when the emergency has passed and there is no longer a tight supply situation.

Whether evolved spontaneously or with the active aid of metal producers, the substitution of plastics for certain metal-forms can provide a stop-gap of great emergency value. In most cases, the passing of the emergency will bring a return to normal design considerations and the recapture of most of the temporarily-lost business to those producers that have zealously and publicly kept their names and the ultimate advantages of their products before the whole of their normal peace-time market.—F.P.P.

letter TO THE EDITOR

Counter-Espionage Activity

To the Editor: Your National Defense Committee assured Mr. Hoover that it would send his letter to all members of The Associated Business Papers with the suggestion that they reproduce this letter of his, urging those of their subscribers who *qualify* to send for this book immediately.

C. A. MUSSELMAN
Chairman, National Defense Committee, A.B.P.

The Hoover Letter to A.B.P.

Gentlemen: In the war-torn world of today America must strengthen her internal and external fortifications if she is to survive the menace of totalitarianism. The protection of our industrial facilities to insure the uninterrupted production of goods and material is essential to our national defense. Based upon this premise the FBI in September, 1939, in accordance with the request of the War and Navy Departments, inaugurated a program to survey the protective facilities of manufacturing establishments having large contracts to provide the government with defense materials. The purpose of the surveys is to submit recommendations to bolster the physical protective facilities of the manufacturing plants for the prevention of sabotage and espionage activities.

The first and final responsibility to give speed and strength to our national defense program by protection against espionage and sabotage lies with industry itself. Only through the energy and alertness of its officials and workers will the full measure of preparedness be attained.

In line with this plant survey program and to assist industrial concerns and municipalities in establishing effective protection against possibilities of acts of espionage and sabotage the FBI prepared a comprehensive booklet entitled "Suggestions for Protection of Industrial Facilities." Because of its confidential nature this booklet is limited in distribution to heads of duly constituted law enforcement agencies and executive officials of industrial concerns manufacturing defense materials under Government contracts.

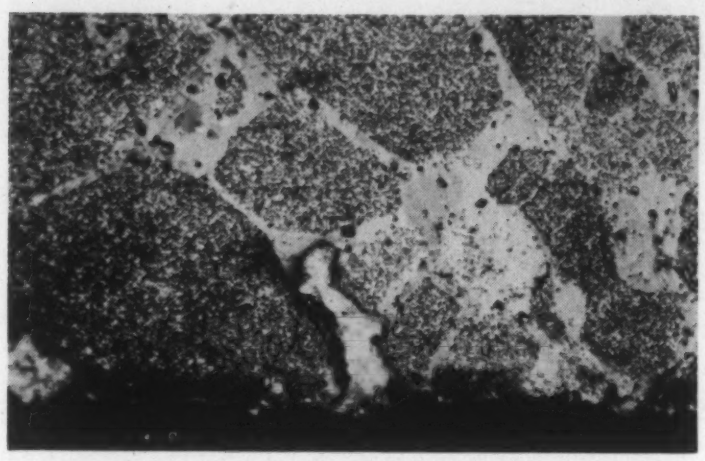
In response to the many questions as to how to obtain this publication I wish to state that a copy will be furnished an industrial concern upon the written request of an executive official.

JOHN EDGAR HOOVER
Director

Chuckles

Another "Find" in Photomicrographs

To the Editor: Here is a photomicrograph of a lead-1 per cent antimony alloy taken by E. E. Thomas, metallographer of our laboratories. You may care to publish it as an ex-



ample of another "find" in micrographs in the appropriate section of METALS AND ALLOYS. To us it seems as if Mutt is doing another worrying act about his friend Jeff.

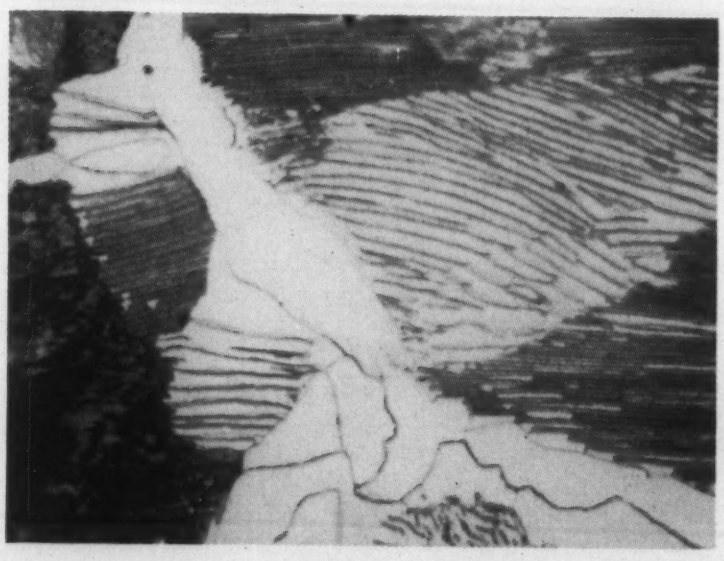
We all get a lot of fun out of these oddities and hope to see more in the future.

E. E. SCHUMACHER

Bell Telephone Laboratories,
New York

A Wild Goose?

To the Editor: I am enclosing a photomicrograph showing a picture of a wild goose. The coarse pearlitic structure



almost looks like an outstretched wing if a little flight of imagination is used.

C. F. PASCOE
Superintendent Steel Foundry Division

Canadian Car & Foundry Co.,
Montreal, Canada.

Scientific Personnel!

To the Editor: The Director of the National Roster of Scientific and Specialized Personnel—the defense tabulation of scientists and technicians, remarks on page 385 of the October issue of the *Scientific Monthly* that it is almost certain that the number to be included in this census will reach "at least the half-*billion* mark." That is, every man, woman, and child in the United States is a scientist four times over.

We're better off than we thought, but aren't some of these merely "on order"?—H.W.G.

Hard on the Technical Chairman!

This is old but was just discovered in a piece on "Nihard" in *Foundry Trade Journal,* Nov. 28, 1935, p. 395:

> Incidentally, the addition of chromium also adds slightly to the hardness of the carbide masses. As the Chairman tends to enter into combination with the carbides, however, it has no very marked effect on the condition of the matrix of the metal.

This seems to be an addition to the manifold duties of the chairman.

J. S. MARSH

Shooting at a Duck on the Water!

To the Editor: Enclosed is a photomicrograph of wrought iron, 1000X. The slag particle has taken the form of a duck, gliding along on the rippled water.

CHARLES NAGLER
Teaching assistant in metallography.

University of Minnesota,
Minneapolis, Minn.

The left-hand part also indicates that some one is indulging in unsportsman-like conduct, shooting at a duck on the water, but only one pellet has hit, and that in the tail.—H.W.G.

A Ruggedness Tester Needed?

To the Editor: Following is a claim which appears in the bulletin of a manufacturer of a coating to prevent carbon penetration in selective areas of steel parts during carburizing. We nominate this for your "Chuckle column."

> "This prevention of carbon penetration not only proves economical in reduced machining costs but also retains the *ruggedness* of the piece when extreme torque or pressure is required, while bearing surfaces are hardened to reduce friction wearing."

As far as we can tell they may be right because our laboratory has no "ruggedness" tester and we hardly know where to obtain one.

JOHN WELCHNER

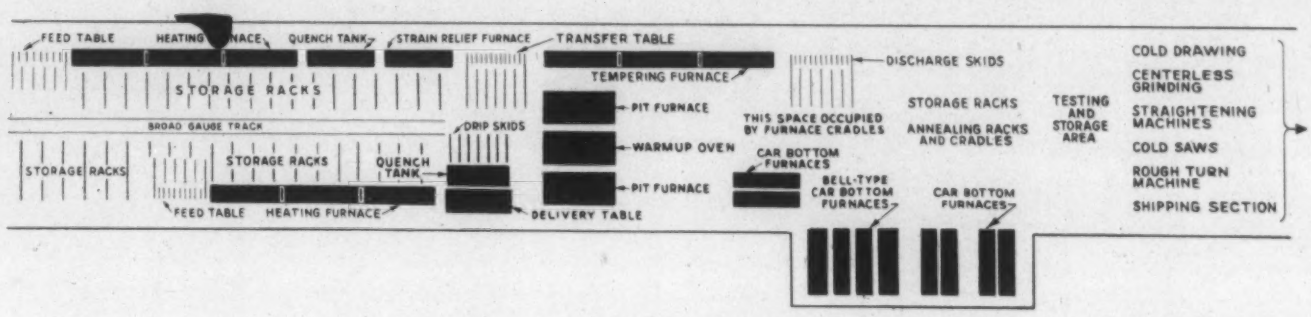
Metallurgical Department.
Timken Roller Bearing Co.,
Canton, Ohio

Heating the Rollers!

"Capital Requirements, a Study in Methods as Applied to the Iron and Steel Industry" by Louis T. Paradiso, under the direction of Gardiner C. Means; a Publication of the National Resources Committee, released by the National Resources Planning Board, Washington, 1940.

Page 15—"Blast furnace gas is used in some mills to heat the rollers."—H. W. G.

Additions to Bethlehem's Electric Heat-Treating Facilities



General plan of the Bethlehem electric heat-treating plant.

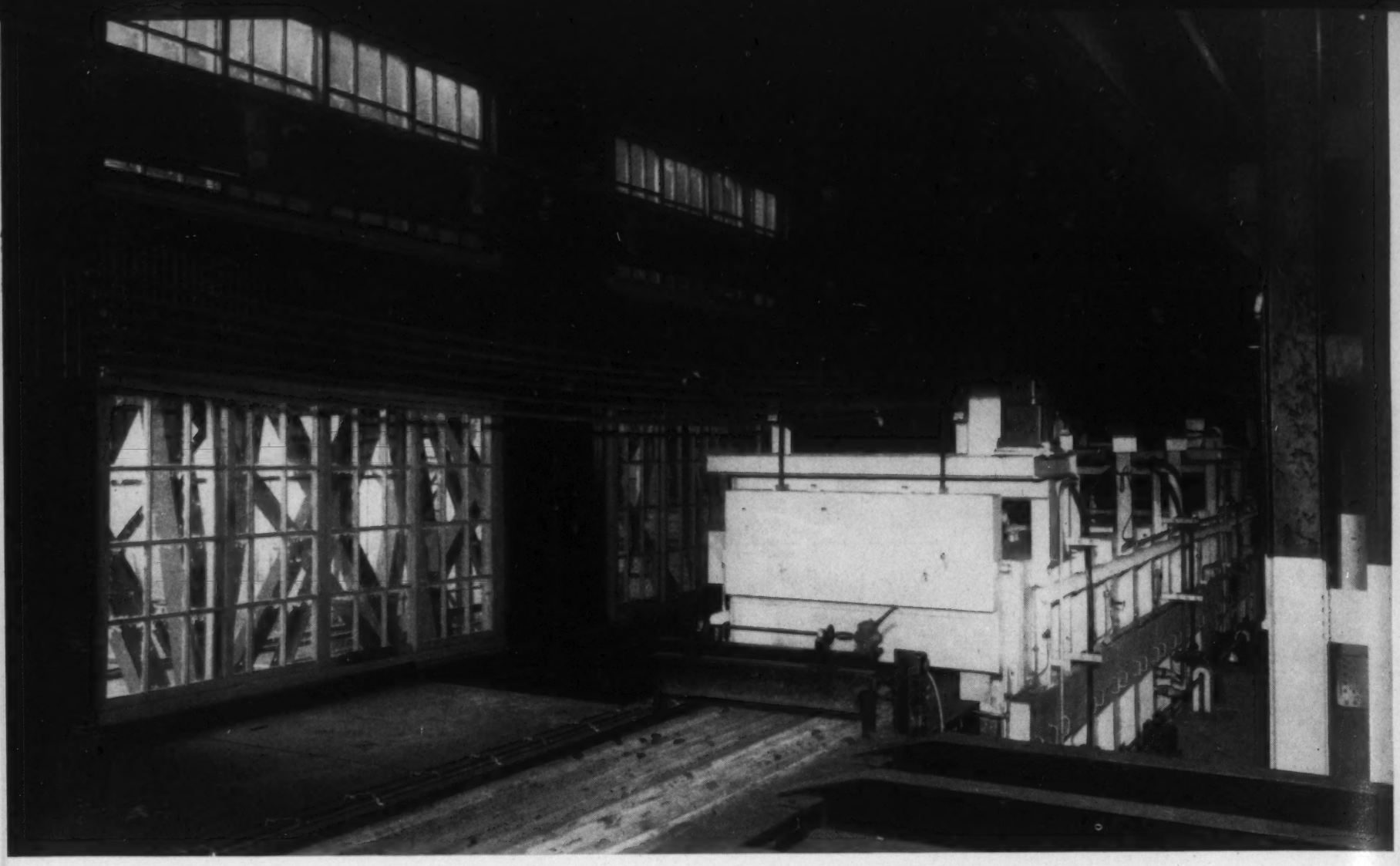
As a result of the national defense program requirements and in order also to meet a growing demand for special carbon and alloy steel bars in the heat-treated condition Bethlehem Steel Co. has again expanded the electric heat-treating division at its Bethlehem Plant, Bethlehem, Pa.

A continuous tempering and hardening line comprising three roller hearth furnaces with a total of seven heating chambers, and a quench tank are a feature of the new installation. Likewise four new car bottom furnaces have been installed. The roller hearth furnaces are of the type installed in 1930 when electric heat treating of bar stock on a large scale was begun at the Bethlehem Plant. Experience has demonstrated that this type of furnace is highly dependable and that uniformity in physical properties can consistently be obtained with it.

The arrangement of the equipment is such that the furnaces and quench tank are operated in a continuous 330-ft. hardening and tempering line. The furnaces are designed for 25-ft. bars from ¼ up to 5-in. cross section. In sequence of operation, the line consists of a heating furnace divided into preheating, intermediate, and high temperature chambers, each with separate doors; a quenching tank for either oil or water quenching; a strain-relief furnace and a tempering furnace which, like the heating furnace, also has three chambers with separate doors.

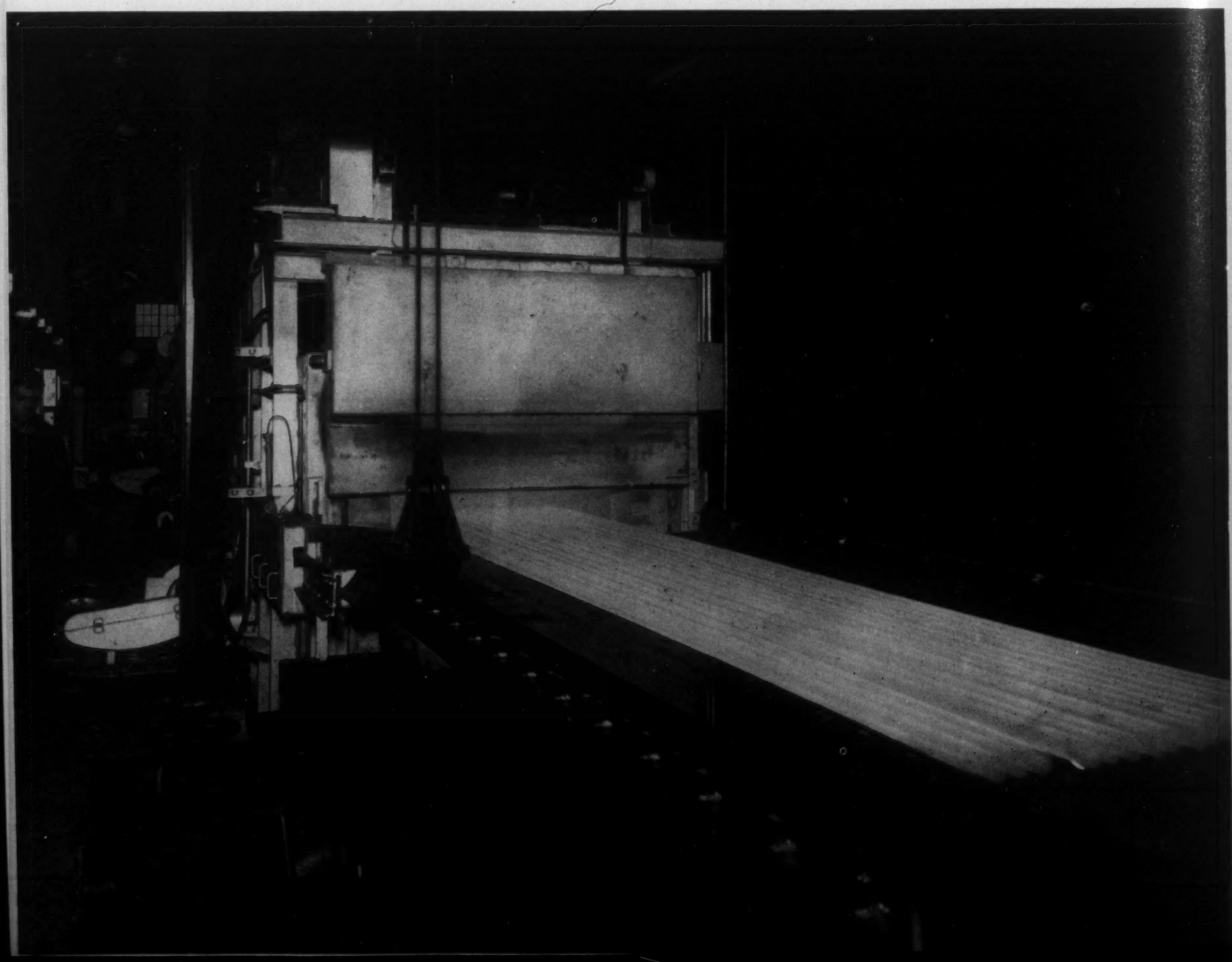
A discharge table and cross-feed conveyor which is located between the strain-relief furnace and the tempering furnace adds flexibility to the unit. Bars that are not to be tempered in the straight line tempering furnace can thus be kicked off at this table in either the normalized or quenched condition after strain relieving and routed to the main shop aisle for further treatment or processing. This dis-

General view of Bethlehem's electric heat-treating department at the Bethlehem plant.



Bars entering the re-heat furnace from the feed table.

Hot bars coming from the high temperature chamber of the heating furnace onto the quench tank rolls.



charge table can be employed not only to by-pass bars to the main shop aisle when desired, but can also be operated in reverse, making it possible if occasion demands to load hardened bars on the roller line at this point for tempering. Chain drives are employed both for the roller line and for all conveyors.

In addition to the roller hearth furnaces, four car bottom furnaces have been installed which can be operated either in conjunction with the new heating and strain-relief furnaces in the hardening and tempering line or in conjunction with existing furnaces. Two of the car bottom furnaces which are to be used in low temperature tempering work have roof fans for better distribution of heat, a feature also of several of the new roller hearth furnaces. Roof fans have not been installed in the other two furnaces as they are operated for annealing at higher temperatures. Although at present all four of the furnaces are operated under normal internal atmospheric conditions, there are pipes so that controlled gaseous atmospheres may be used if desired at some future time.

The added equipment, including both the new hardening and tempering line and the new car bottom furnaces, is expected to approximately double Bethlehem's electric heat-treating capacity, which, previous to the installation of the new equipment, was the largest in existence for the treatment of bars. New construction required for housing the added equipment called for widening the existing building and adding two additional bays to its length. Additional shipping space as well as the necessary space for the new equipment has also been provided. This is the third important expansion of the department. The second major expansion was made in 1937 when bell-type car bottoms and strain-relief furnaces were installed.

The chief innovation as contrasted to the 1930 installation is the straight-line arrangement of equipment for hardening and tempering which entirely does away with handling material by crane in this operation. It is only when charges from the roller hearth furnace are by-passed for tempering or annealing that crane handling is necessary.

A number of minor innovations tend to promote further refinement of practice. Thus the new furnaces are equipped with more rolls of smaller diameter than those installed in 1930. Rolls in the new furnace are on 12-in. rather than 18-in. centers as in the older furnaces. The closer spaced rolls carry the bars better and facilitate the handling of stock of smaller cross section. The straight-line arrangement is particularly advantageous in quenching, as the load is run out directly from the high temperature furnace to the quenching cradle without intermediate handling, thus shortening the time from furnace to quench and insuring against excessive cooling, of smaller sizes, prior to entering the quenching medium. As further insurance against excessive cooling, the rolls of the high temperature furnace and quench table rolls are independently powered by variable speed motors that make possible variation in run-out speeds from 100 to 300 ft. per min.

All seven separate chambers of the roller hearth furnaces including the three chambers of the heating furnace, the single chamber of the strain-relief furnace and the three chambers of the tempering furnace are 29 ft. long inside. Both the strain-relief furnace and the tempering furnace, however, are wider than the heating furnace, measuring 5 ft. 6 in. in width as compared to the 4 ft. 6 in. width of the heating furnace. This greater width in the strain relief and tempering furnaces is provided to supply sufficient room so the bars will lie as evenly as possible on the rolls after the bowing or distortion that normally results from quenching.

Heating units in the three-chamber heating furnace are mounted in the roof and on the side walls underneath the rolls. Those in the first or preheating chamber are rated 420 kw., divided into two approximately equal groups of 210 kw. each. In the intermediate chamber the units are divided into three groups, the two end groups being 105 kw. each, and the middle group 210 kw. The units in the high temperature chamber, capable of being heated to 1650 deg., are rated at 209 kw. and consist of two end groups, each rated 52 kw., and one middle group rated 105 kw. The total electric rating of the heating furnace is 1049 kw., 220 volts, 3-phase, in 8 control groups.

The quench tank which is 10 ft. deep by 29 ft. long is designed for oil or water quenching but is expected to be employed mainly for oil quenching. It is connected with a thermostatically controlled cooler in which the quenching medium is strained as well as cooled. Circulating water is the cooling medium. A storage tank has been provided for convenient replenishment of the quenching oil.

Quenching equipment is mounted integrally with the quench tank and consists of a roll table upon which the bars may be run out and a super-structure which mounts a hoist mechanism and drive that lowers the roll table and its load of bars into the quenching fluid, oscillating them up and down under the control of a timer.

The roll table is driven by a separate motor which can be matched for run-out purposes to the speed of the rolls in the high temperature furnace, and the run-in after quenching can similarly be matched to the speed of the rolls in the strain-relief furnace.

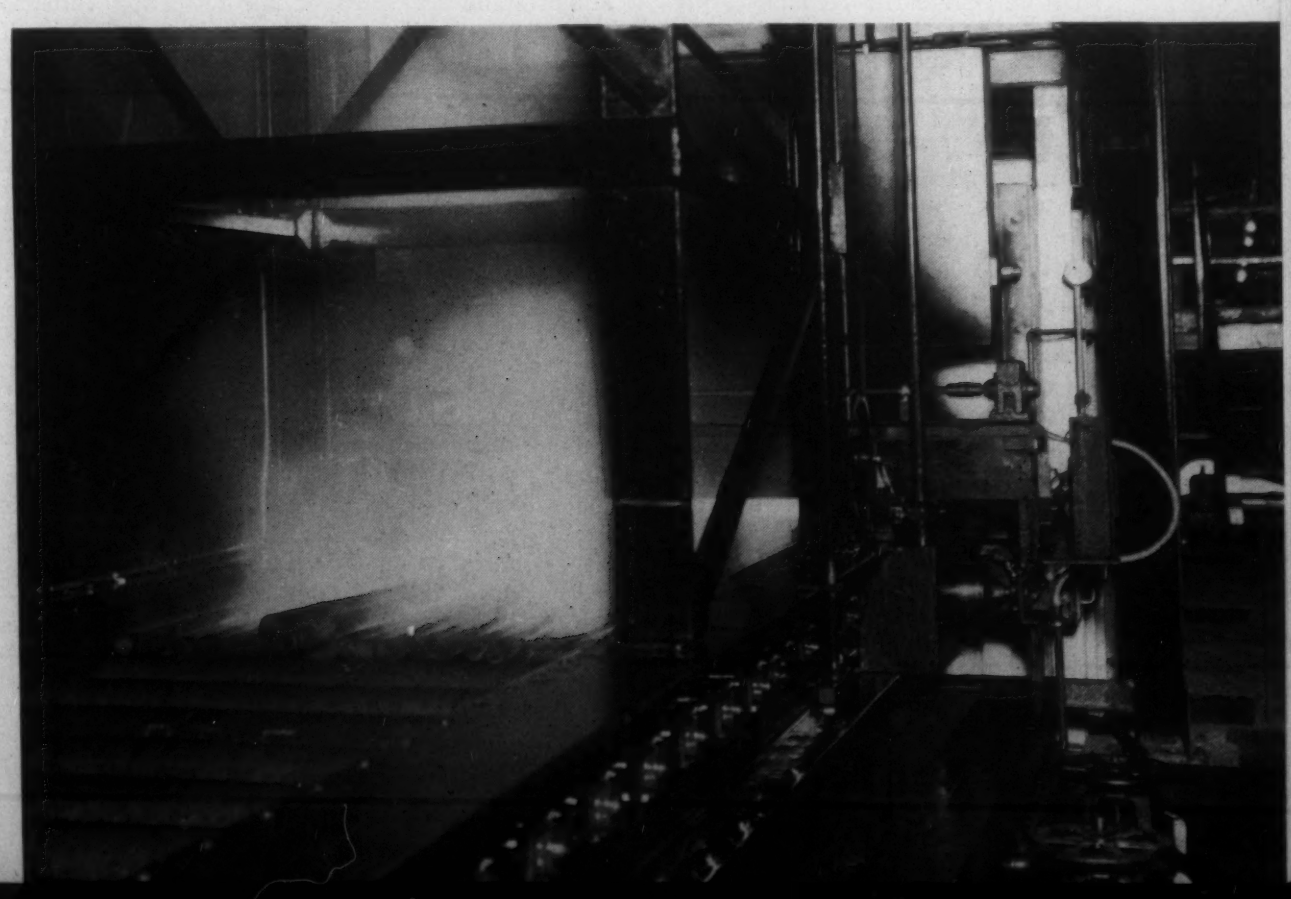
Roof fans are a feature of both the strain-relief furnace and also the tempering furnace. The strain-relief furnace is equipped with three of these fans and each of three chambers of the tempering furnace is similarly equipped. The fans in both furnaces are driven at 3-h.p. AC motors with V belt drives. The fans are made of heat resisting cast alloy. Initial operating experience indicates that these fans are of material benefit adding to the effectiveness of the heating units as well as promoting efficient distribution of heat.

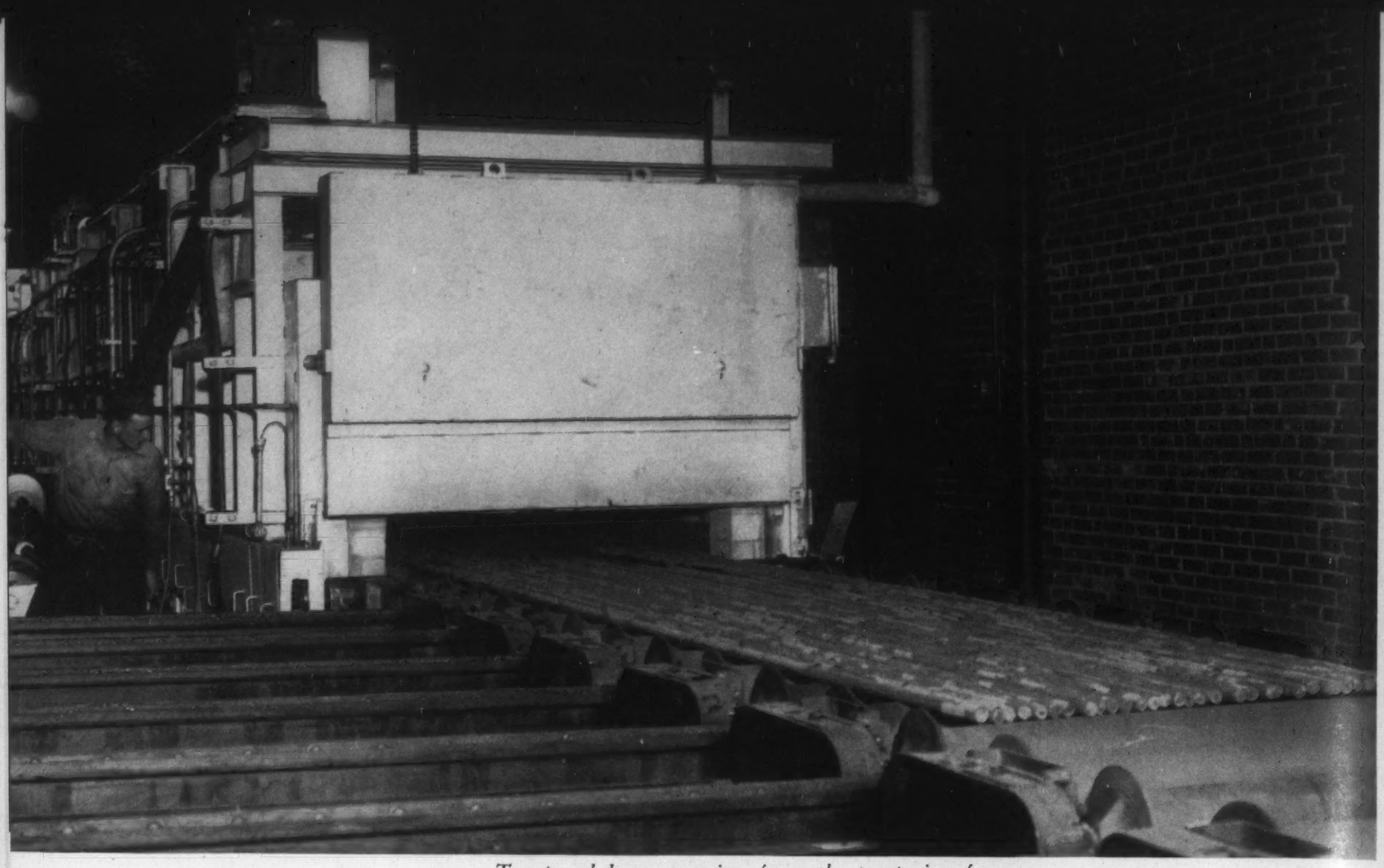
Since the roof fans increase the effectiveness of the roof heating units in the strain-relief furnace, side-bottom mounted units which are a feature of the other two furnaces in the line are dispensed with in this furnace, thus obviating trouble from short circuiting that might result from the relatively heavy fall of scale that takes place as the bars come from the quench. The strain-relief furnace has an electrical rating of 315 kw., 220 volts, 3-phase divided into three sections at 105 kw. each.

The tempering furnace as has been indicated comprises three chambers. Each chamber has an electrical rating of 315 kw., the heating units being divided into 3-105 kw., 220 volts, 3-phase sections. Total rating is 945 kw., 220 volts, 3-phase. While normal requirements will be for temperatures ranging from 950 to 1200 deg. F., the furnace is capable of producing temperatures up to 1550 deg. F., a provision which would make it feasible to operate the furnace as an annealing or normalizing unit should occasion demand. The heating units in the tempering furnace are located both in the roof and on the side walls under the rolls, as in the heating furnace, and like the strain-relief furnace it has roof fans.

Chromel-alumel thermocouples of ap-

Bars entering the strain relief furnace following quenching.





Tempered bars emerging from the tempering furnace.

propriate length are provided for all the furnaces, also chromel-alumel duplex wire for thermocouple leads. Indicating type temperature control instruments are employed on flush panel mountings, including watt meters, watt-hour meters and 2 current transformers for the total power to each of the three furnaces. Each control board is also equipped with contactors and relays, and main-line disconnect switches for each of the furnace chambers.

A combination of line-shaft drives and individual motor hook-ups provide the power for operating the rolls, furnace doors and other mechanized equipment. The feed table and the rolls in the preheat and intermediate and high temperature chambers are driven from a line shaft geared to a 15-h.p. direct current motor. Sprockets, that take off from the line shafting, drive the feed table, preheat and intermediate heating furnace rolls at a speed that carries the bars at 50 ft. per min. The rolls in the high temperature furnace, however, are provided with a separate 5 h.p. 3/1 speed motor capable of running out loads of hot bars at 100 to 300 ft. per min. A 5-h.p. motor of this type also operates the quench table rolls. The roller tables for the three chambers of the heating furnace are connected together by magnetic clutches at all times except when under hand control for run-out or run-in. In order to promote uniform heating and prevent cold spots on the bars, the rolls are continuously rocked during the treatment cycle. This practice also prevents sagging of the rolls when larger sizes are being treated; involving heavier loading and requiring longer treatment. The rocking mechanism is powered by a 2-h.p. motor.

The doors of the heating furnace, with the exception of the run-out door, are operated by a 5-h.p. direct current motor with line shafting and speed reducers, while the door for the outgoing end of the high temperature furnace has a separate 1-h.p. motor. The quench hoist, strain-relief roll table, and the rolls in the strain-relief furnace are all separately operated by 5-h.p. motors, while a 2-h.p. motor operates the doors of the strain-relief furnace. A 5-h.p. motor operates the cross-feed hoist and a 10-h.p. motor operates the cross feed travel rolls. The rolls in the tempering furnace and of the discharge table are driven from a main line shaft with a 15-h.p. motor in the same manner as the feed table rolls preheat the intermediate heating furnace rolls, and are geared for travel at 50 ft. per minute. The six doors of the tempering furnaces are mechanically interlocked and can all be operated from a line shaft powered by a 5-h.p. motor. All motors are for 30-min. rating except those on the rocking drives which are for continuous rating.

Main control cubicles, containing the contactors and relays, are located on a gallery or platform structure above the furnaces. Control stations, or operators' panels, mounting the necessary push buttons are located at conveniently accessible points for all phases of treatment.

Assuming that a load of bars is in each of the heating chambers, the cycle of operation is as follows: The operator pushes the run-out push button raising the end door of the high-temperature furnace and disconnecting its roll table from the main drive. When the end door is fully open, the roll table of both the high temperature chamber and quench table are started and the bars are run out on the quenching table, striking a limit switch that starts a motor which lowers the bars into the quench, and automatically raises and lowers them for a time determined by their size and composition. Then the operator pushes the run-in button which opens the other five doors of the heating furnace, running untreated bars from the feed table into the pre-heat furnaces, preheated bars from this chamber to the intermediate chamber and the bars in the intermediate chamber into the high temperature chamber. Separate hand controls enable the operator to jog the roll tables back and forth to set the bars in position in any one of the three chambers if necessary. The travel of the bars in the strain-relief and tempering furnaces is similarly controlled.

At the transfer table, located between the strain-relief furnace and tempering furnace, the travel of the bars may either be continued into the tempering furnaces, or they may be by-passed as has been indicated, for annealing or tempering.

From the discharge table the bars go to the finishing departments for testing, machine straightening, centerless grinding, cold drawing or other final processing as required. Adjacent space that had been utilized in billet preparation has been taken over to provide increased area required for operations incidental to loading and shipping such as marking, bundling, weighing, tagging and final analysis identification by spark testing. Space that was formerly used for shipping and storage is now available for the increased volume in testing and straightening resulting from the enlarged treatment facilities.

METALLURGICAL ENGINEERING news

Equipment
Finishes
Materials
Methods
Processes
Products

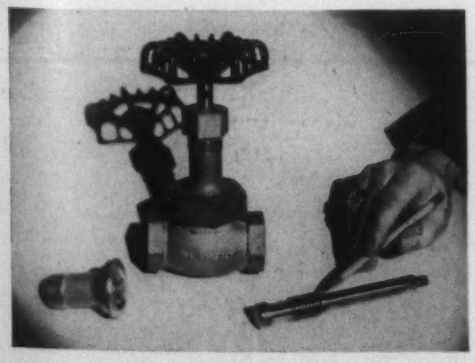
Alloys
Applications
Designs
People
Plants
Societies

Non-Ferrous Metals In Engineering Design

The importance of non-ferrous alloys in metallurgical engineering design has been emphasized by recent articles in these columns on an improved aluminum bronze (Jan., p. 57), a new type of Monel metal (Jan., p. 57), a new bearing bronze (Jan., p. 59), the selection of alloys for die castings (Jan., p. 58), and copper tubing with soldered fittings (Feb., p. 178), and feature articles and digests on magnesium alloy die castings (Feb., p. 145), new heat-treatable copper-cobalt-silicon alloys (Feb., p. 151), and aluminum Diesel engine parts (Feb., p. 228). Several other recent non-ferrous design developments that are worthy of mention are discussed below.

Longer Wearing Valve Stems

A new self-lubricating alloy for valve stems and bonnets is described by *Hancock Valve Div.* of *Manning, Maxwell & Moore, Inc.*, Bridgeport, Conn., as outwearing other stems and bonnets several times in repeated breakdown tests.



Known as Hancodur, the alloy has a tensile strength of 90,000 lbs. per sq. in. plus good resistance to galling and wear. It was developed expressly for Hancock superfinished "500 Brinell" bronze valves.

Improved Doctor Blades

In soap manufacture the doctor blades that scrape the soap from the drying rolls are often made of English razor steel. In one large plant, the considerable delay involved in stopping production for 10 min. during each 8-hr. shift to hone the steel blades led to the application of heat-treatable "K" Monel metal for this service. According to the *International Nickel Co., Inc.*, New York, doctor blades made of "K" Monel required such relatively few rehonings as to permit the soap plant to boost its production 3,750 lbs. a week.

New blades are never removed with "K" Monel more than once every 60 hrs., so that the performance ratio in favor of the new blades is more than 7:1, it is said.

New Applications of Aluminum

The commercial availability of a new process for photographic printing directly on sensitized aluminum is announced by *Republic Engineering Products, Inc.*, 480 Lexington Ave., New York. With this process, using sensitized aluminum in sizes from 5x7 to 22x34 in. and in thickness from 0.006 to 0.010 in., copies can be made directly on metal by the usual contact printing method or with an enlarger from an ordinary drawing, print or negative.

No special treatment or expensive equipment is necessary in processing. Because of its slow speed, this sensitized metal film requires no special dark room for its handling. The advantages of metal photographic film of this type include its resistance to high temperatures, and to rough handling, special appearance effects, adaptability for template work, etc.

Another interesting use for rolled aluminum, according to *Reynolds Metals Co., Inc.*, Federal Reserve Building, Richmond, Va., is the packing and shipping of bacon in a flat aluminum foil envelope with a Pliofilm lining. Such containers are reported to preserve color, prevent moisture loss or absorption, and retard the development of mold and rancidity.

Hard Chromium Plate

In Europe the process of "porous chrome-hardening" has been reported in wide use for increasing the wear and running properties of cylinder walls, piston rings, bearings, etc. in Diesel, gasoline and steam engines, in compressors, pumps and pneumatic systems, for crankshaft bearings, cross-head guides, etc.

The process, which consists of the controlled deposition of a very hard and oil-absorbing porous film of chromium on the parts in question, is to be made further available to American metallurgical designers through the establishment at Olean, N. Y., of a new plant of the *Van der Horst Corp. of America.* At present, 2 important chrome-hardening plants are already being operated under Van der Horst's licenses—those of the American Hammered Piston Ring Div. of Koppers Co. at Baltimore, and the Naval Aircraft plant at Philadelphia.

Spot Welding Timer

Designed to eliminate the necessity of an air or hydraulic pressure switch in resistance welding and to provide accurate timing control for any air-operated, stationary or portable, single or multi-spot welder, the Model 75 electronic timer has been added to the line of *Weltronic Corp.*, 3071 East Outer Dr., Detroit. The new timer features a minimum of moving parts and the elimination of a pressure switch, and insures a minimum of maintenance costs and down-time, it is said.

A repeating timer eliminates the need for a pressure switch and requires one additional timing function. The 4 adjustments required are "squeeze-time," "weld-time," "hold-time" and "off-time." The timer will compensate for the effects of lower room temperatures or extreme distance from pressure switch to welder. The 4 adjustments are made by dialing control knobs on the front of the panel. This new timer is available for use with either a magnetic or Ignitron tube contactor, and is standard for 110 v., 60 cycles.

New Blast Furnace Brick Design

A new firebrick design for blast furnace linings known as the "Agnew Design" has been introduced by *Harbison-Walker Refractories Co.*, Farmers Bank Bldg., Pittsburgh. The design is such as to permit a stronger, more permanent lining construction, with a smaller proportion of clay in the joints.

In the new brick design, the section perpendicular to the long axis is shaped like a parallelogram, and is not rectangular. Each brick is tapered on its long dimension, and is placed with the smaller end toward the inside of the lining. Laying the brick on edge instead of on flat gives a stronger construction, with better stress distribution in the lining, it is said. This type of construction also reduces the number of horizontal joints in the lining by 50 per cent.

The brick in the new design come in 2 lengths—9 in. and 13½ in. Four sizes are made as rights and lefts, thus giving 8 shapes, which serve for linings of any diameter from 10 to 38 ft., and of any thickness. No cutting is required for thicknesses that can be formed by using a combination of the 9 in. and 13½ in. long brick.

The edge-laid bricks form courses 6 in. high and all joints are broken, there being less possibility of "creeping," it is said, than occurs with the conventional linings built with a combination of flat-laid keys and straights.

● Notable short cuts in manufacturing are said to be available through the use of Turchan follower machines developed for precision duplicating of dies, molds, patterns, rolls, form cutters, etc. The machine is said to greatly increase the capacity of standard boring mills, lathes, planers, etc., by permitting the operator to follow the pattern being copied and transferring control of the shape to be cut to the cutting tools. The machines are sold by *National Purchasing Co.*, 405 Boulevard Bldg., Detroit.

Welded Steel-Mill Cranes

Pictured under construction here is what is believed to be the world's largest all-welded trolley-frame for a heavy-duty steel-mill type crane of 150-tons capacity. The frame alone will weigh 32½ tons and have an overall length of 23 ft., 5 in. and width of 15 ft., 6 in. In its fabrication at the plant of *Cleveland Crane & Engineering Co.*, Wickliffe, Ohio, 276 pieces of various thicknesses are being welded together, prior to machining of the whole.

After the frame has been welded into a 1-piece unit, it will be accurately machined in the same manner as a huge casting. By machining the frame as a whole rather than in individual sections, perfect alignment and proper bearing seats are said to be assured. The crane for which this frame is intended is one of 3 to be used in heavy defense work.

Some Plant Expansions

Allegheny Ludlum Steel Corp., producer of alloy steels for machine tools, aircraft engine valves and other defense equipment, is increasing the capacity of its Brackenridge, Pa., plant about 4,000 tons per month through the installation of 2 additional electric melting furnaces plus the necessary rolling mill equipment. . . . *Arcos Corp.*, Philadelphia, announces an addition to its stainless electrode manufacturing plant that will increase its capacity 100% and permit acceleration of delivery schedules.

Cooper Alloy Foundry Co., makers of alloy and stainless steel castings, valves and fittings, has added a manufacturing unit in Hillside, N. J., which now houses the laboratories and machine shop and will shortly be augmented by electric melting furnaces. . . . *Union Carbide and Carbon Corp.*, New York, is planning to build on the West Coast a combined calcium carbide and ferro-alloy plant, which will also include facilities for the production of manganese- and chromium-bearing alloys.

The entire cutlery division of *Remington Arms Co.*, Bridgeport, has been acquired by Pal Blade Co., and will be moved to Holyoke, Mass. . . . *Kester Solder Co.*, Chicago, has purchased the property now occupied by their Newark division and plans further expansion and improvements on this site. . . . According to *Glenn L. Martin Co.*, Baltimore, Md., building operations have started on an Omaha, Neb., plant designed by Martin and to be built by the Army for the assembly of Martin bombers.

● According to a British executive of *Lincoln Electric Co.*, 12818 Coit Rd., Cleveland, the use of larger-size arc welding electrodes has been a major factor in the successful British speed-up of production on vital equipment. With the larger electrodes, welds are made at much faster rates since more metal is deposited in a given time, and it is believed that their full utilization in America would save thousands of much-needed man-hrs.

Foundry Mold Spray-Gun

A new gun for the spraying of molds with the various coating compounds used in foundries has been developed by *Binks Mfg. Co.*, 3114-3140 Carrol Ave., Chicago. The gun is of the siphon type and has no fluid valve incorporated in it.

The gun has been built to withstand the extreme abuse to which it will be subjected in the ordinary foundry. Two models are available—a very fast gun for large molds, and a gun with a finer spray for small molds where the finish must be carefully watched. In either model the price of the gun is $12.50.

● A new Magni-Master model, of 4½ times magnification, for illuminated optical inspection of metal parts, machine work, dies, tools, etc., is applicable where higher-than-ordinary magnification is required, states its manufacturer, *Mizzy, Inc.*, 105 E. 16th St., New York.

SPECIAL PERICLASE

(Fused Magnesia)

CEMENTS

Help in the Production of Special Nickel Alloys

In the melting of special alloys close control is essential and this involves initial test runs in high-frequency furnaces in advance of plant production. Norton Fused Magnesia (Periclase) Cements can be applied as a lining to graphite crucibles used for this exacting work. In this way both the desirable strength qualities of a graphite crucible and the added life of a magnesia crucible can be achieved in one operation.

A catalog giving full information on Norton Refractory Cements—not only Fused Magnesia but also **ALUNDUM** (fused alumina) and **CRYSTOLON** (silicon carbide)—will be sent on request. And Norton engineers are glad to give you the benefit of their experience in handling heat.

NORTON COMPANY, WORCESTER, MASS.

New York Chicago Cleveland

NORTON REFRACTORIES

New Corrosion-Resistant Material

A brand new corrosion-resistant material (non-metallic) said to be highly useful (1) as a lining for pickling, plating and cleaning solution tanks, (2) as a molded or extruded material for resisting chemical corrosion, and (3) as a protective coating or sheathing for parts requiring extra corrosion resistance, has been developed by *United States Stoneware Co.*, Tallmadge, Ohio.

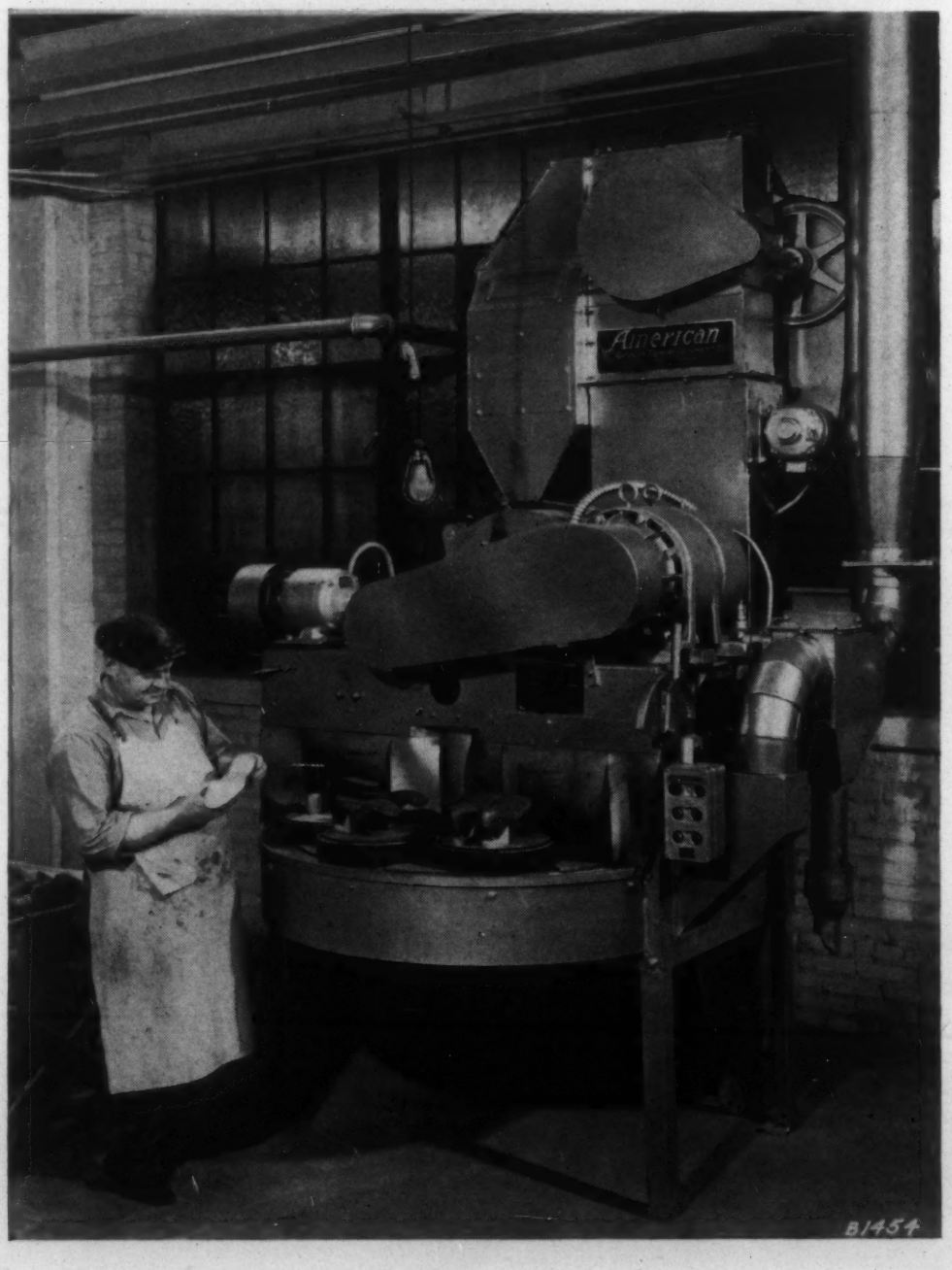
Known as "Tygon," the new material may be formed into a patent-leather-like material for application as a lining for metallurgical and chemical processing equipment; into a rubber-like resilient compound for flexible sheets, tubes and molded goods; or into a liquid for spraying, dipping or painting surfaces exposed to corrosives. Tygon is unaffected by practically all inorganic and organic acids, alkalies and salt solutions (except glacial acetic and fuming nitric acids).

The new material's chemical stability approaches that of chemical stoneware, although, unlike the latter, Tygon is completely immune to hydrochloric acid. Unlike rubber, which it resembles physically, Tygon resists oxidizing agents and many hydrocarbons. It may be quickly repaired if damaged.

Tygon linings, it is said, may be used with a great variety of different solutions. When used for coating plating hooks, it eliminates the necessity of frequent, expensive deplating of hooks, reduces current losses and prevents fouling of the solution. It is described as on a par with rubber in first cost and remarkably low in maintenance costs. It can be applied to wood, metal or concrete.

Where small parts normally deteriorate rapidly from corrosive action, they can be molded or extruded from Tygon, it is claimed, to give tubing, rods, gaskets, pulleys, etc., that are highly corrosion resistant and satisfactorily durable.

Roughening Metal Shoe-Lasts



The gentleman with the satisfied expression pictured above is examining a magnesium last that has been roughened by blasting with No. 18 metallic grit in a Wheelabrator Multi-Tablast unit manufactured by *American Foundry Equipment Co.*, Mishawaka, Ind. The machine consists of a series of rubber-covered tables that revolve as they pass through the blasting area, two lasts being placed on each table.

The magnesium lasts at this plant (Clark Metal Last Co.) are roughened to provide an anchor for a metallized thin coating of carbon steel sprayed onto the sole of the last. This combination gives a leather-shoe metal last that is light and far more durable than wood, yet presents a hard surface that bends the nails over after they are driven through the sole instead of permitting them to penetrate into the last-metal.

New Welding Materials

New very-low-temperature oxyacetylene welding materials, formerly available only from Switzerland, are now being produced and distributed in this country by *Weldoloy Mfg. Co.*, a division of *Park Sales Co.*, 3 Park Pl., New York. The unusually low temperatures at which these materials (alloy rods and powder and paste fluxes) are used avoids overheating and warping of welded parts, it is said.

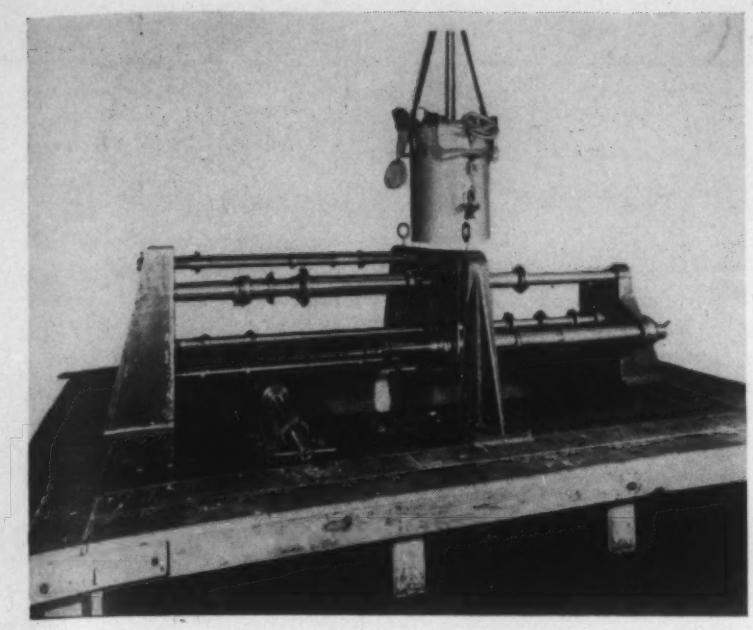
Weldoloy 690 is used for the welding of aluminum alloys, flows at 930 deg. F., and has a tensile strength of 35,000 lbs. per sq. in. Weldoloy 685, used for build-up and repair welding on steel, cast iron, copper, brass, bronze, etc., flows at 750 deg. F. and can be easily machined even though its hardness is 230 Brinell, it is said. Other alloys are individually designed for joining cast iron, or steel, or copper alloys, or zinc-base die castings, etc.

Extra-Heavy Contour Sawer

The new V-60 Doall contour machine for the continuous sawing, filing and polishing of variously shaped metal parts has been designed expressly for heavy duty in ordnance plants, aircraft shops and shipyards, according to *Continental Machines, Inc.*, 1301 Washington Ave., So., Minneapolis.

The 5-ft. throat depth of this machine permits the cutting of work up to 10 ft. in diameter, and thus offers special possibilities for the machining of large templates or irregular shapes. Thicknesses up to 12 in. can be cut. This model includes as standard equipment a "super butt welder," which joins the 1-in. saw blades just as readily as the 1/16-in. blades—both of which the machine can use. An illuminated magnifying attachment is also provided when intricate layout lines are to be sawed.

● An interesting application of the Corronizing process, developed by *Standard Steel Spring Co.*, Coroapolis, Pa., is for protecting thermostat elements manufactured by Robertshaw Thermostat Co. The Corronizing coating, a specially bonded, thin, non-porous, nickel plate, protects the bulb end, which is exposed in the corrosive oven atmosphere, and thus insures a long, trouble-free life for the elements. The equipment for the Corronizing plant, which operates at the rate of over one million parts per year, was made and installed by the *Hanson-Van Winkle-Munning Co.*, Matawan, N. J.



Castings

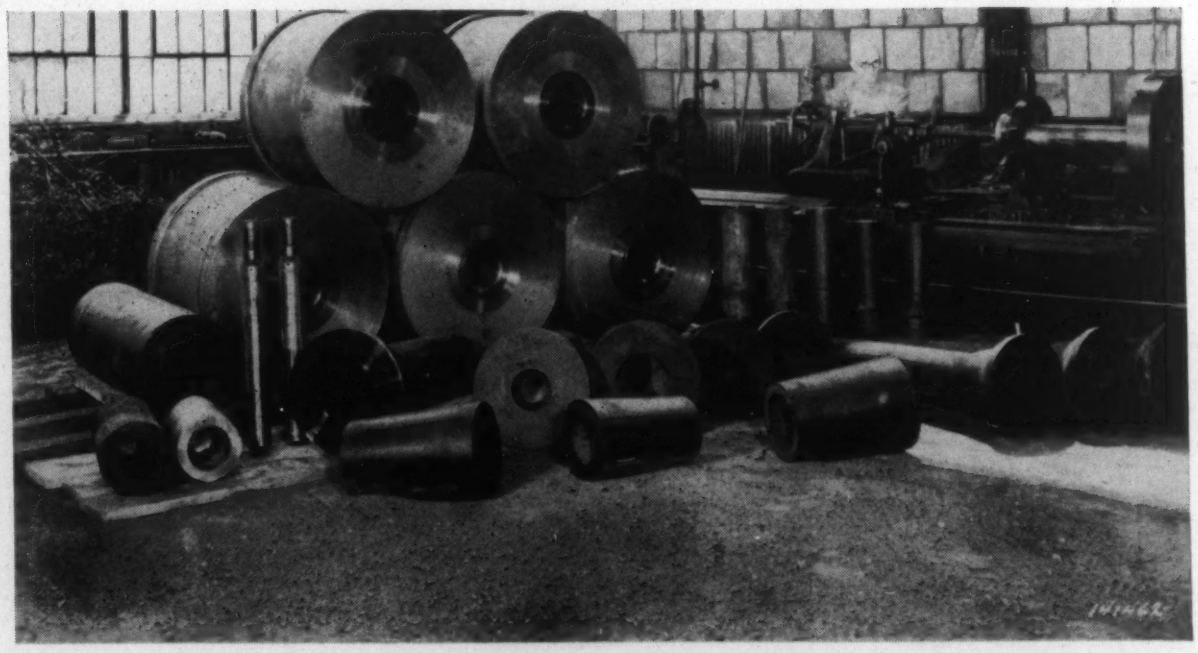
In a new line of simple and economical automatic shell machines designed by the Machine Tool Builders Assn. for extra-fast production, all large planing and boring operations and all machining operations on the main casting have been eliminated. Carriages and swinging arms are supported on longitudinal bars, instead of planed way surfaces. These bars (as well as the spindle, shafts, etc.) run in bushings that are cast in place in the main base of the machine, using the illustrated pouring fixture for locating and supporting the bushings on pilot bars.

The bushing metal that makes all this possible is a low-melting-point bismuth-lead-tin alloy (of the "Cerro-matrix" type) that expands slightly on freezing. It is also employed for the seat on which the cover plate rests.

Metallurgical Engineering vs. Time!

Forgings

Machining has largely replaced grinding to speed up production of very-hard forged alloy steel rams and liners for the extrusion of copper, brass and aluminum, reports Carboloy Co., Inc. At Ajax Steel & Forge finishing time was halved by machining these heat-treated forgings with cemented carbide tools rather than by grinding, with a saving of 1 hr. or more per piece.



Weldments

Fabrication of up to 20 tons per day of structural steel with spot welding by means of the recently announced resistance "forge-welding" process is showing savings of upwards of 30% of the time previously required to do the same work by punching and rivetting or by arc welding, according to Progressive Welder Co. Illustrated here is the start of final fabrication by the new process of a 20-ft. long steel strut assembly at Taylor & Gaskin, Inc., with three thicknesses of metal being welded together.

Control Instruments

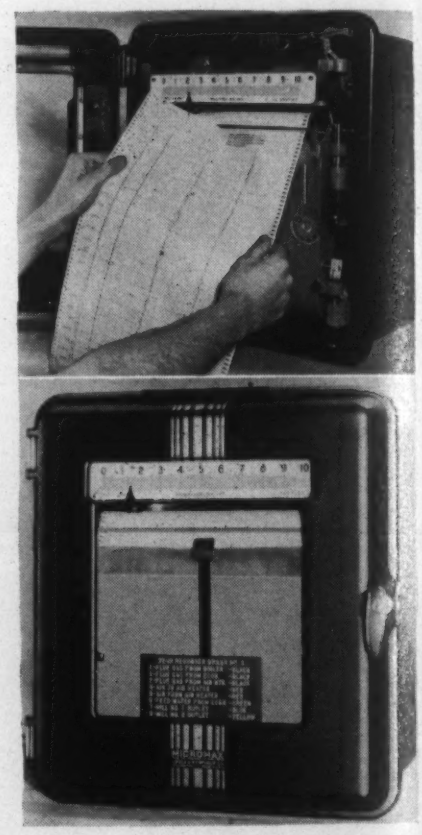
Among recent new developments in the field of temperature control equipment are 3 items of notable interest. *The Bristol Co.*, Waterbury, Conn., announces the addition of a new throttling type air-operated temperature controller to its line of free-vane automatic control instruments. Known as Bristol's Pre-Set Free-Vane temperature controller, the new instrument is designed for processes where there is a tendency for the temperature to exceed the control setting of the instrument on the initial rise—in other words, where there is likely to be over-shooting of the control point in starting up.

In such processes—for example, in heat control of jacketed cooling units—the Pre-Set controller introduces a pre-setting effect that is proportional to the width or throttling range and also the rate of charge of the condition being measured and controlled.

For heat treating applications that require a peculiar combination of control equipment all incorporated in an automatic system, *Brown Instrument Co.*, Philadelphia, has developed a completely flexible program control system using Brown potentiometer controllers. The basic instrument is usually a single-point indicating or recording pyrometer, although it is possible to use the 2- or 3-record controllers controlling at the same temperature.

In order to accomplish a given program of temperature control, the control index of the potentiometer controller must be moved automatically from one point to another, either up-scale or down-scale. The movement of this control index is governed by a control-point drive-motor mounted in the instrument. A temperature may be held for a certain number of hours without any movement of the control index by employing a timer in the system. An outstanding advantage of this type of program control system is that it can control multiple-zone furnaces from one master program.

The users of Micromax strip-chart recorders can now tear off and file a record of each day's operation by installing the new daily tear-off device for such recorders just announced by *Leeds & Northrup Co.*, 4934 Stenton Ave., Philadelphia. The device fits modern Micromax recorders and thus provides daily strip-chart records in a form as convenient to file as those from round-chart



recorders, yet with a more detailed record plus multiple-point recording. The cost is between $10 and $15, depending on whether a time-stamped paper is used.

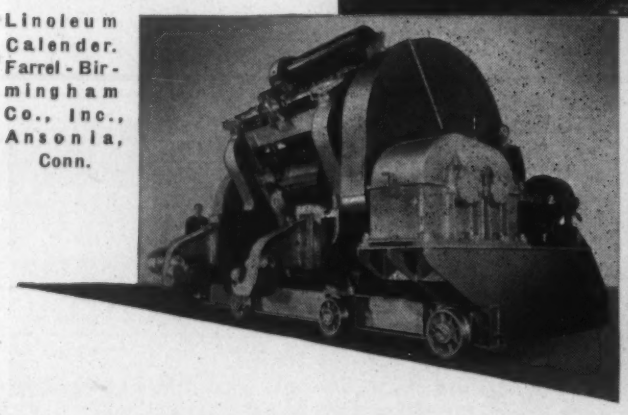
Sheet Steel Thickness Gage

A new magnetic gage, which is claimed to provide for the first time a method of measuring the thickness of sheet steel when only one side is accessible, has been invented by W. E. Abbott and B. M. Smith of *General Electric Co.*, Schenectady, N. Y. The gage is accurate to 1/1000 of an inch and offers means of rapid determination of the uniformity of material and a check against expensive over-thicknesses.

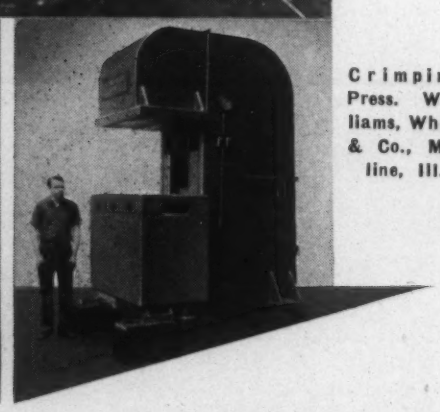
The thickness of any magnetic sheet or plate material may be measured by the gage as long as the material is not backed by other magnetic material. The gage is especially valuable for checking the center and other points on wide sheets of steel where the use of calipers is inconvenient or impossible.

not 2 or 3 but 7...

electrodes for mild steel welding



Linoleum Calender. Farrel-Birmingham Co., Inc., Ansonia, Conn.



Crimping Press. Williams, White & Co., Moline, Ill.

There are not just 2 or 3—but 7 Murex rods for welding mild steel alone—characterized by ability to handle easily, to operate at high currents and to produce sound, clean welds. Each is different enough to permit you to choose a rod exactly suited to the particular application, so that you can be assured of the utmost in the quality of your work, plus the lowest possible welding costs.

An important part of Murex service is engineering advice on different and unusual welding jobs. We have helped hundreds of manufacturers improve their welding and save production time. Perhaps we can do the same for you.

MUREX HEAVY COATED ELECTRODES

METAL & THERMIT CORPORATION • 120 BROADWAY • NEW YORK
ALBANY • CHICAGO • PITTSBURGH • SO. SAN FRANCISCO • TORONTO

THERMIT WELDING — STANDARD FOR 40 YEARS FOR WELDING RAILS AND HEAVY EQUIPMENT

● Two new metal-to-metal and phenolic-to-phenolic adhesive solutions made of Vinylite resins produce strong, impact-resistant bonds, and are known as XL-5041 and XL-5075, according to the *Plastics Div.* of *Carbide and Carbon Chemicals Corp.*, who produce the Vinylite plastic as a raw material.

Spectrochemical Film Dryer

The use of films in spectrographic analysis is rapidly increasing for both grating and prism spectrographs. A new infra-red film dryer, available from *Harry W. Dietert Co.*, Detroit, will dry a 16-in. length of 35 mm. film in 50 sec. without curling the film. The wet film is stretched around a glass form as shown in the illustration.

An infra-red lamp is located within the glass form and a motor-driven fan in the base of the dryer forces warm air around

the outside of the glass form. The air used by the dryer is filtered to keep dust away from the emulsion. An electric timer starts and stops the blower and cuts off the current to the lamp after pre-determined drying times.

News of Metallurgical Engineers

C. L. Foreman has been made chief metallurgist of the new aircraft engine division of Buick Motor Div., General Motors Corp., Flint, Mich. . . . *J. C. Ward, Jr.*, has left his post as general works manager, Rome Mfg. Co., to become president of Fairchild Engine & Airplane Corp., New York. . . . *T. I. Phillips,* formerly general works manager of Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has been appointed assistant to the president.

S. Allan Jacobs, general sales manager of Inca Mfg. Div. of Phelps Dodge Copper Products Corp., New York, has been elected a vice-president of the company. . . . *P. D. Merica,* assistant to the president of International Nickel Co., Inc., New York, has been twice honored in recent weeks: He received a platinum metal from the Council of the Institute of Metals in Great Britain for "distinguished services to non-ferrous metallurgy," and was selected to give the first George Kimball Burgess Memorial Award Lecture of the Washington Chapter, American Society for Metals, on Feb. 10th.

Thomas E. Dunn, instrumental in the development of the Bullard-Dunn electrochemical descaling process, has, because of ill health, resigned as director and works manager of the Bullard Co., Bridgeport, Conn. . . . His capacity as works manager will be filled by *F. P. Whitworth.* . . . *Otto A. Pfaff* is now president and general manager of American Foundry Equipment Co, Mishawaka, Ind. . . . *Ashland Henderson,* formerly metallurgist with Frigidaire, is now at Battelle Memorial Institute, Columbus, Ohio, assigned to the development of corrosion- and wear-resistant metal surfaces.

Wm. G. Theisinger has been promoted to director of welding research of Lukens Steel Corp., Coatesville, Pa. . . . Acme Steel Co., Chicago, recently announced the elevation of *Guy T. Avery* to the position of works manager of their Riverdale plant. . . . *J. Heber Parker,* formerly vice president of Carpenter Steel Co., Reading, Pa., has been elected president to succeed the late Fred A. Bigelow. . . . *W. A. Cather* has been appointed "product development manager" of Seamless Steel Inst., Pittsburgh, Pa.

FURNACE PERFORMANCE and HOW!

Write Today for Bulletin No. 81-E

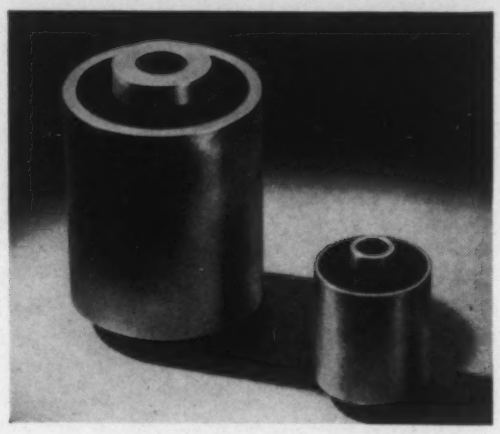
New records reported in straight line control—work chamber uniformity—processing speed—material handling efficiency and fuel economy. Unsolicited letters of Despatch furnace users are testimony to their actual operating superiority. See Bulletin No. 81 for diagrams of heat dynamics and illustrations of new features showing how Despatch furnaces outperform all others. It contains information about Despatch "controlled combustion "direct gas fired air heater, oil fired heater and Despatch electric heating system.

DESPATCH OVEN COMPANY MINNEAPOLIS MINNESOTA

Aircraft Engine Mountings

A new line of "Torflex" aircraft engine and cowl mountings employing Neoprene (for resistance to oil and high-altitude ozone) and 18/8 stainless steel (for resistance to low-altitude salt air corrosion) is announced by *Harris Products Co.*, 5407 Commonwealth Ave., Detroit, Mich. The mountings are also available in general industrial applications where operating conditions require both Neoprene and stainless.

Process of manufacture consists of stretching a seamless Neoprene tube between inner and outer tubes of stainless steel and then permitting the Neoprene to seek its initial state. In doing the latter, the Neoprene forms a high capacity mechanical bond with the stainless steel tubes, with a rated capacity of 150 lbs. per sq. in. axial load. The process is said also to permit the manufacture of special sizes or small quantities at low cost.



● A simple and effective permanently installed gage for speeding-up the setting and assuring the accuracy of adjustment of cutting tools on multiple-station automatic machinery has been developed by a large automobile company, reports *Carboloy Co., Inc.*, Detroit. The gage consists of a U-shaped swivelling forging, the arms of which are pinned to the tool holder so that the gage can be quickly swung down for checking or resetting the tools.

Air-Cooled Welding Torch Nozzles

A source of annoyance to operators working on light-gage metals in confined areas, or on very heavy castings or plate, has been the familiar overheating of welding torch nozzles. *Victor Equipment Co.*, 844 Folsom St., San Francisco, however, are now marketing an air-cooled nozzle

called the "Airadiator"—a radiator-like section made of aluminum and provided with disk-like fins.

The very large cooling area of the fins is claimed to keep the tubular section cooler than the ignition temperature of the fuel gas and thus to eliminate popping, hissing or back-firing. The torch handle is also kept comfortably cool.

● A new self-operated temperature regulator has been specially designed by *Sarco Co., Inc.*, 183 Madison Ave., New York, to control the heating medium in degreasers and thus prevent boiling over of vapors, loss of solvent and rust formation in the degreaser.

Special High Grade ZINC

Guaranteed 99.99+% Pure

WHEN you choose Anaconda Electric for the base of Zinc die castings, you are certain of obtaining uniform, dependable metal. For every slab of Anaconda Electric Zinc is electrolytically refined and guaranteed 99.99+% pure.

Anaconda Electric Zinc is supplied in 50 lb. slabs clearly marked "Anaconda Electric 99.99+%." Whenever you use this well-known brand, whether in small quantities or carload lots, you may be sure that *every slab will test 99.99+% pure.*

39392

Shipping Point: Great Falls or Anaconda, Montana

ANACONDA
from mine to consumer

ANACONDA SALES COMPANY
25 Broadway, New York
Subsidiary of Anaconda Copper Mining Company

Abrasion Tester for Surface Finishes

For evaluating the resistance of surface finishes—paints, lacquers, electroplates, plastic surfaces, etc.—to rubbing abrasion, the *Taber Instrument Co.*, No. Tonawanda, N. Y., has developed the new research model Taber Abraser. The new instrument incorporates many improvements over earlier models particularly an adjustable-weight system, permitting varying pressures of the abrading wheels against the specimen as required by the particular type of material being tested,

The primary elements of the Abraser are the motor-driven turn-table on which the specimen is mounted, a counter to indicate the number of abrasion cycles, and 2 abrading wheels that alternately rub back and forth and at the same time criss-cross in their rolling path. These wheels are made in 5 types of closely controlled resilient material charged with special grades of fine abrasive grain.

● A new grade of Koroseal, named "Koroplate," has been developed by *B. F. Goodrich Co.*, Akron, Ohio, specifically to protect metal surfaces against corrosion, and is recommended by them for service wherever extremely corrosive conditions disqualify other types of paint or coating. The new paint is liquid at room temperature, requires no heating before application, and can be either brushed or sprayed.

● Something of a novelty is the Welding Exhibit to be held under the sponsorship of the Northern New Jersey section of the *American Welding Society*, March 21 and 22 at the Mosque Theater Terrace Room, Newark, N. J. The purpose is to bring together the manufacturers of welding equipment, welded products, and the many industrial companies in this territory in one great showroom.

Meetings and Expositions

AMERICAN SOCIETY OF TOOL ENGINEERS, annual meeting. Detroit, Mich., Mar. 24-29, 1941.

NATIONAL MACHINE & TOOL PROGRESS EXHIBITION. Detroit, Mich., Mar. 25-29, 1941.

AMERICAN CERAMIC SOCIETY, annual meeting. Baltimore, Md., Mar. 30-Apr. 5, 1941.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, spring meeting, Atlanta, Ga., Apr. 1-3, 1941.

AMERICAN CHEMICAL SOCIETY. St. Louis, Mo., Apr. 7-11, 1941.

ELECTROCHEMICAL SOCIETY, spring meeting. Cleveland, Ohio, Apr. 16-18, 1941.

AMERICAN PETROLEUM INSTITUTE, division of production. Pittsburgh, Pa., Apr. 17-18, 1941.

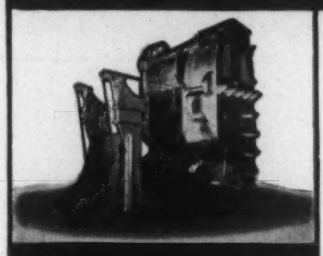
AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, national open hearth steel conference and blast furnace and raw materials committee meeting. Chicago, Ill., Apr. 23-25, 1941.

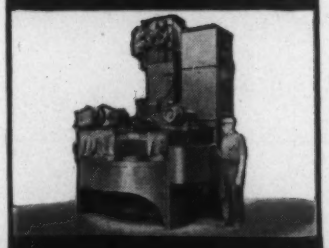
Free Service Department

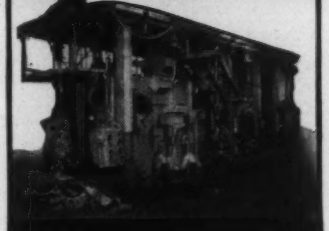
Replies to box numbers should be addressed care of METALS AND ALLOYS, *330 W. 42nd St., New York.*

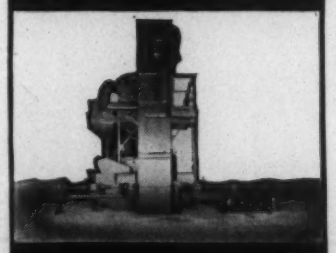
HELP WANTED: Materials Engineer, required by East Coast Aircraft Engineering Laboratory. Metallurgical experience in aluminum and steel alloys required. A knowledge of aircraft materials and their uses will also be valuable. Give complete details regarding training, experience and salary in first letter. Box MA-4.

AIR AND AIRLESS BLAST CLEANING


ROTOBLAST BARRELS


ROTOBLAST TABLES


SPECIAL ROTOBLAST


SPECIAL ROTOBLAST

AIR BLAST ROOMS

In this unpredictable year of 1941 every day holds a challenge to our American way of freedom. Each twenty-four hours must be marked by unprecedented production of those things that will make our Nation STRONG.

●

The products of the Pangborn Corporation are recognized by both industry and government as vital tools necessary in today's National Defense Program.

●

Blast Cleaning — airless ROTOBLAST and Air — is essential to every metal finishing process in large and small Foundries.

●

Here are pictured the Pangborn blast cleaning and dust collecting "tools" which this very minute are everywhere upping production and lowering cleaning costs as they produce more uniformly finished work than ever before.

●

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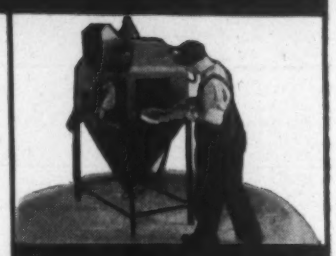
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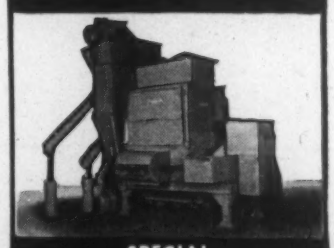
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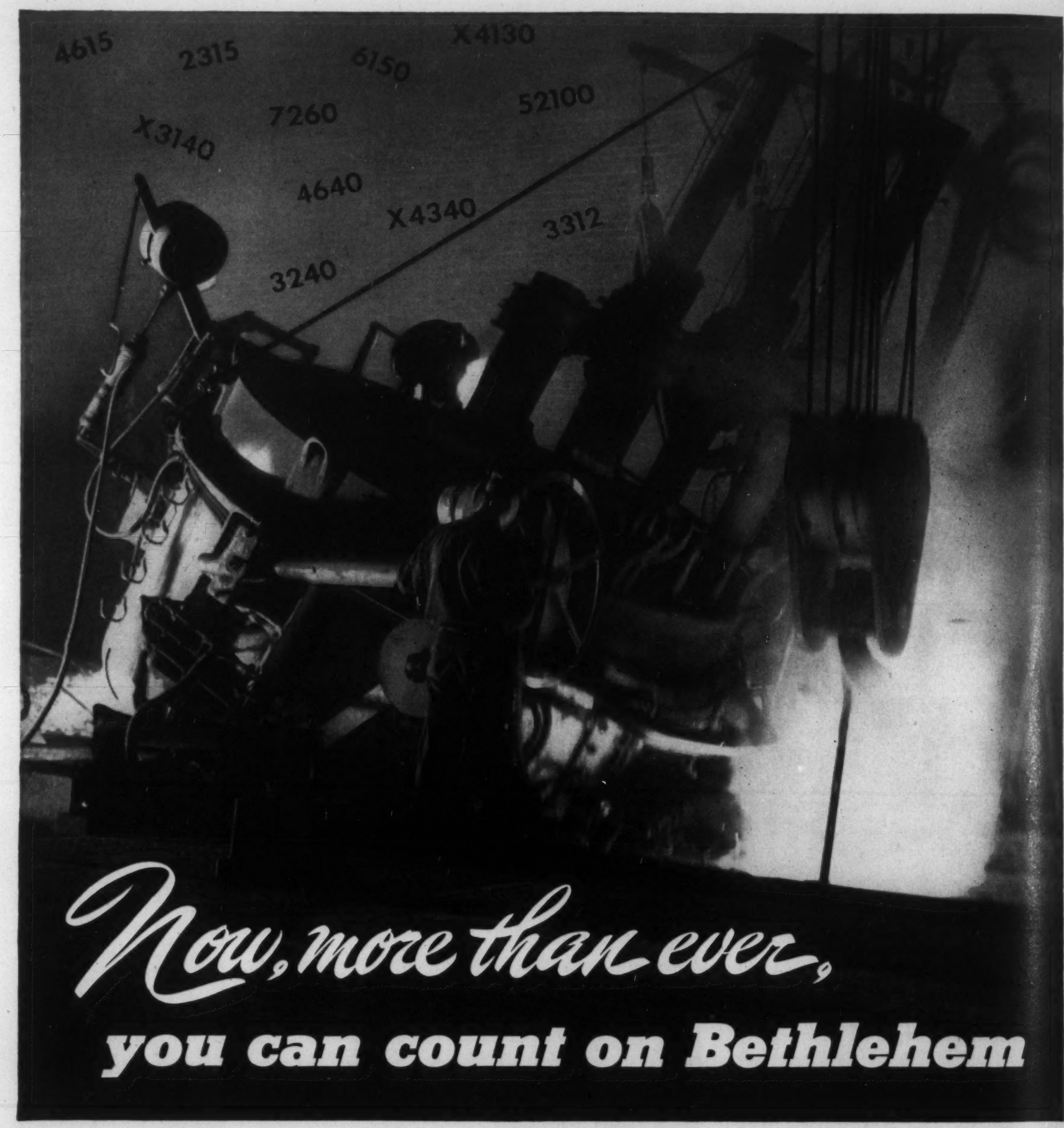

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METALLURGICAL ENGINEERING

shop notes

Spherical Pivot Formed in Die Casting

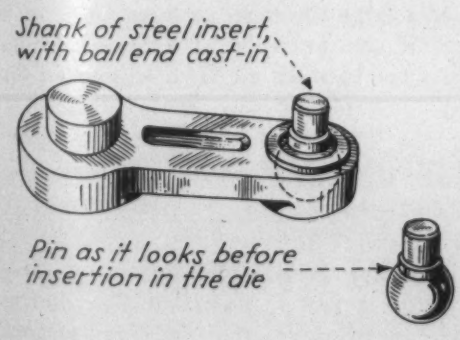
by Bert E. Sandell

Stewart-Warner Die Casting Div.,

Stewart-Warner Corp.

Among the products of the author's company are windshield wipers that require linkages operating at odd angles. We have discovered an interesting way of making, by die casting, a lever arm with a pivot pin that gives a sort of universal action, which may have analogous application for others.

The link is a small zinc alloy die casting in which the pivot pin at one end is cast in place as an insert. This pin is of steel and is produced with one end spherical, as shown in the accompanying illustration. It is a very simple insert to



make in a screw machine and has a cylindrical shank that protrudes from the die casting and affords a means for holding the insert in the die; the die is merely provided with a hole in which the shank fits.

This, of course, leaves the ball end protruding into the die cavity. The spherical portion is substantially covered with the zinc when the casting is made, only a small area near the end of the axis of the ball remaining uncovered. The die casting, of course, provides a matrix around the sphere, and in freezing, grips the sphere securely.

After casting, however, the pin is struck in a press while the casting is held securely, the blow being such that the spherical pin moves axially about 0.002 in., deforming the spherical seat this small amount, and causing it to be fractured. As the spherical pin surface is quite smooth and does not freeze permanently to the metal die-cast around it, the blow gives the ball end just enough play to permit it to be turned and also to oscillate within the spherical seat formed by the casting.

There is no machine work required to form the seat and the latter is in 1 piece, whereas a seat formed in 2 pieces would be required otherwise and an assembly operation, avoided in this case, would be needed to put together 2 parts with the ball between. Yet in this simple and inexpensive way, the pivot pin is given the precise degree of universal motion required, being free to rotate and to oscillate.

Avoiding Hot Breaks in Brass

by R. S. Pratt

Bridgeport Brass Co.

Although the brasses are among the easiest to fabricate of all materials, occasionally an unusual combination of conditions will cause trouble in operations normally performed without trouble. A typical instance is the occurrence of "hot breaks"—intercrystalline cracks (with a distinctive discoloration) caused by a combination of heat and stress.

Many metals and alloys are brittle at specific temperatures. With high brass, Muntz metal and some other copper-zinc alloys this brittle range is between 500 and 750 deg. F. The more rapidly force is applied, the more pronounced the brittle effect becomes and the higher is the temperature at which brittleness occurs. From the practical standpoint there are several operations in which such brittleness may occur if suitable precautions are not taken.

For example, in removing brass parts from an annealing furnace before cooling or on dumping into a quench tank, if the hot parts are allowed to strike against the container or against each other, cracks may be developed, particularly if the parts are heavy. The difficulty is easily prevented by air or water cooling before moving the annealed parts.

This general type of failure is most likely to occur in machining operations. Dull drills are very likely to set up the combination of heat and stress that causes hot breaks. Proper coolants or lubricants are extremely important in operations which develop high stresses as in drilling and tapping.

The trouble may also occur in the rolling or beading of cylindrical shells. Here the cause is the heat developed by the slippage of the shell on the arbor, or between the roll and the shell, while the stress is provided by the rolling deformation. Similar cracking may also develop in buffing if the buffing mandrel is tapered slightly to grip the shell being buffed. Cracking during buffing may also occur in shells that contain high residual stresses from previous drawing or forming operations.

In all these cases cracking results from an unusual combination of circumstances. The remedy in each case must depend on the individual conditions, but the general nature of each solution will be predicated on recognition that the underlying cause is the combination of heat and stress.

(More Shop Notes on Page 320)

Hints for Grinding Sheet Steel

by E. T. Larson
Norton Company

Precision grinding on flat-rolled sheet steel is invariably for finishing the part to an exact thickness or producing smooth and accurate surfaces. The grinding wheels employed should be of aluminum oxide abrasive, vitrified bonded, coarse to medium grit size, and soft grade.

Sometimes cold-rolled sheet steel of very light gage will curl after removal from the grinding machine. This is caused by the relief during grinding of stresses set up in the initial cold rolling. The remedy is to rough-grind both sides of the part, straighten (by peening), and then finish-grind to size.

To prevent uneven heating and distortion of the work during grinding, use a copious supply of coolant, light cuts, and a rapid table traverse.

It often happens in surface grinding very light gage sheet steel that the pattern of the chuck is reproduced on the surface being ground, as a result of the uneven distribution of the magnetic force from the chuck. The consequent tiny dips in the ground surface can be eliminated by shutting off the current to the magnetic chuck before the final light pass or two. The residual magnetism in the chuck will hold the work in place. Air chucks are also used for holding light gage sheet steel parts on the table of the grinding machine.

Sometimes pits, scale and heavy die marks make it necessary to polish, with either a coated abrasive wheel or a sanding belt. Where the operation can be done with one wheel, No. 120 alundum grain is usually satisfactory. If a roughing operation is necessary, No. 80 grain is recommended.

Solder "Streamlines" Auto Bodies

by Bruce W. Gonser
Battelle Memorial Institute

Even in the modern automobile there are still a few seams that must be welded or joined in the final assembly. At these places irregularities, gaps, rough spots, uneven surfaces, etc. are unsightly and must be corrected. A perfectly smooth surface can be readily obtained over welded seams and other irregularities by applying an excess of tin-lead solder to these areas and subsequently dressing down to a uniform surface.

Solder is admirably suited for this purpose because it adheres firmly, melts and flows easily and is soft enough to be readily removed. Its main function is that of a metal filler, much as beeswax is used by a pattern-maker in perfecting his wooden patterns.

Before applying the solder, the high points on the steel sheets are hammered down, and the surface is ground or steel-brushed to clean it. The surface is then brushed with a flux of zinc chloride acidified with hydrochloric acid, or with hydrochloric acid followed by zinc chloride; in some cases ammonium chloride and a small amount of an organic wetting agent may be added to the flux.

The fluxed surface is then heated by a blow-torch, a small quantity of solder applied, and the whole area "tinned" by rubbing the solder over the surface with a cloth. The solder used for tinning can be of the same composition as the solder subsequently used for wiping, but for better tinning action it should be of a higher tin (50/50, say) variety.

After "tinning," the bar solder for wiping is heated to the pasty state by a blow-pipe and spread on the surface, or alternately poured in place from a ladle. The solder in place is further heated, if necessary, and is molded into shape with a wooden trowel soaked in linseed oil or beeswax. The solder commonly used contains about 25 per cent tin, although solders with 19-39 per cent tin and up to 1% antimony may be employed.

When the solder has been roughly formed to shape, it is dressed down fairly close to the desired contour by power-driven abrasive disks, sanding belts or hand rasps, care being taken to protect the workers from breathing the lead-tin dust. In the final dressing treatment emery paper is applied by hand until the proper contours, as judged by an experienced eye, are obtained. The completed joint is then washed and may be sprayed with oil to prevent corrosion.

Porosity of the solder must be particularly avoided, as it causes trouble when the finish is applied.

—*Tin and its Uses,* Tin Research Institute

Dry ice can be used in place of chill-bars or clamps when arc welding stainless steel or other light work subject to easy distortion from overheating. Simply place the dry ice on the work immediately before welding, and the temperature-lowering will be enough to eliminate much of the buckling, warping and rippling often encountered.

—*The Stabilizer,* Lincoln Electric Co.

Some Tips on Quenching Practice

by G. B. Berlien
Lindberg Steel Treating Co.

The most common commercial quenching media are fresh water, brine, oil, hot salt, hot lead, air and special atmosphere. Because fresh water is often responsible for soft spots, its application is limited to the quenching of 18 and 8 stainless in annealing, and to the quenching of aluminum alloys (brine leaves a corrosive deposit on aluminum).

Brine used for water-hardening steels should be a 7-10% (by weight) solution and should be used at 70-100 deg. F. Quenching oil should be about the same temperature. Hot drawing oil can be used for hot-quenching high-alloy steels, but the danger of passing the flash point is present when quenching large sections. Hot-lead at 700-1000 deg. F. is a lifesaver for heavy sections of both straight high speed and cobalt high speed steels.

Brine is used for all straight carbon steels and some low-alloy S.A.E. carburized steels of heavy sections, like S.A.E. 3120 and 6120. The salt lowers the vapor tension of the water so that steam pockets break up readily and even cooling is promoted.

Brine quenching should be done at a 45° angle rather than straight down, so that the bubbles will pass directly up through the brine, rather than travel along the part and thus keep fresh brine away from it. Short lengths of drill rod can be rolled into the quench by means of a flat trough, placing the drill rods in the trough one by one with a tong and allowing each to roll into the quench sideways.

Light sections that do not require full hardness can be chilled with a wet rag or by dipping in oil before quenching the entire part. Also, tools that do not require full hardness of the whole section can be held so that the brine quenches only the portion required to be hard, and the entire tool then quenched in oil. This practice aids in avoiding cracked heads or shanks and gives greater strength to those portions where only toughness is required.

Quenching forging die blocks made of water-hardening steels can be done so as to leave the back soft. To do this the face is quenched over a heavy stream, leaving the dovetailed section out of the quench. A small stream of water, insufficient for hardening, can be played over the part out of the quench to keep it from warping.

Hot salt at about 350-400 deg. F. is an excellent quench for oil-hardening steel dies that tend to warp and crack in the regular oil quench. Good hardness will result with very little change in shape.

If a large die tends to warp while cooling, it can often be straightened by directing a blast of air from a hose on the high side of the die. This will tend to shrink that side and pull the die around better than a press could.

Difficulty experienced with sand eating into the surface of aluminum alloy castings and complicating the finishing problem may be caused by too-soft ramming of the sand. The condition may be overcome by harder ramming and by placing chills all around the outside diameter of each step. The chills will make the metal set more rapidly and will tend to reduce surface defects. The addition of 2½-3 lbs. of titanium-aluminum to each 100 lbs. of molten aluminum alloy in the furnace will also aid by reducing sub-surface pinholes.

—*Better Castings,*
Niagara Falls Smelting & Refining Corp.

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Metallurgical Engineering Digest

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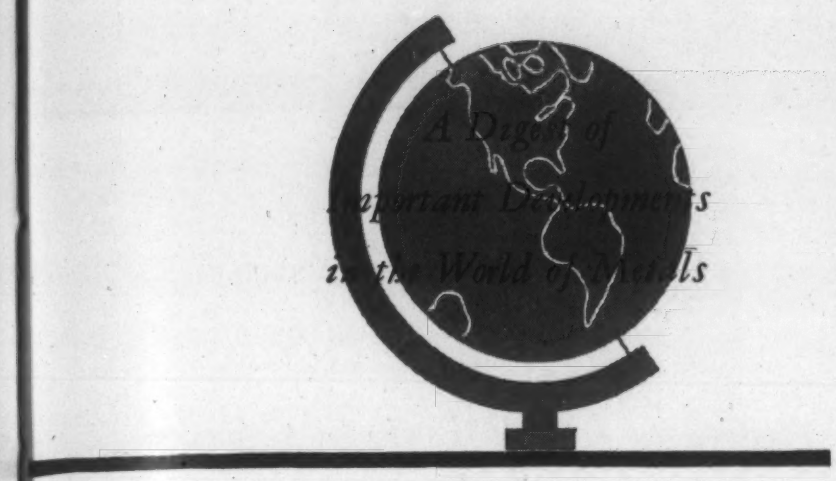

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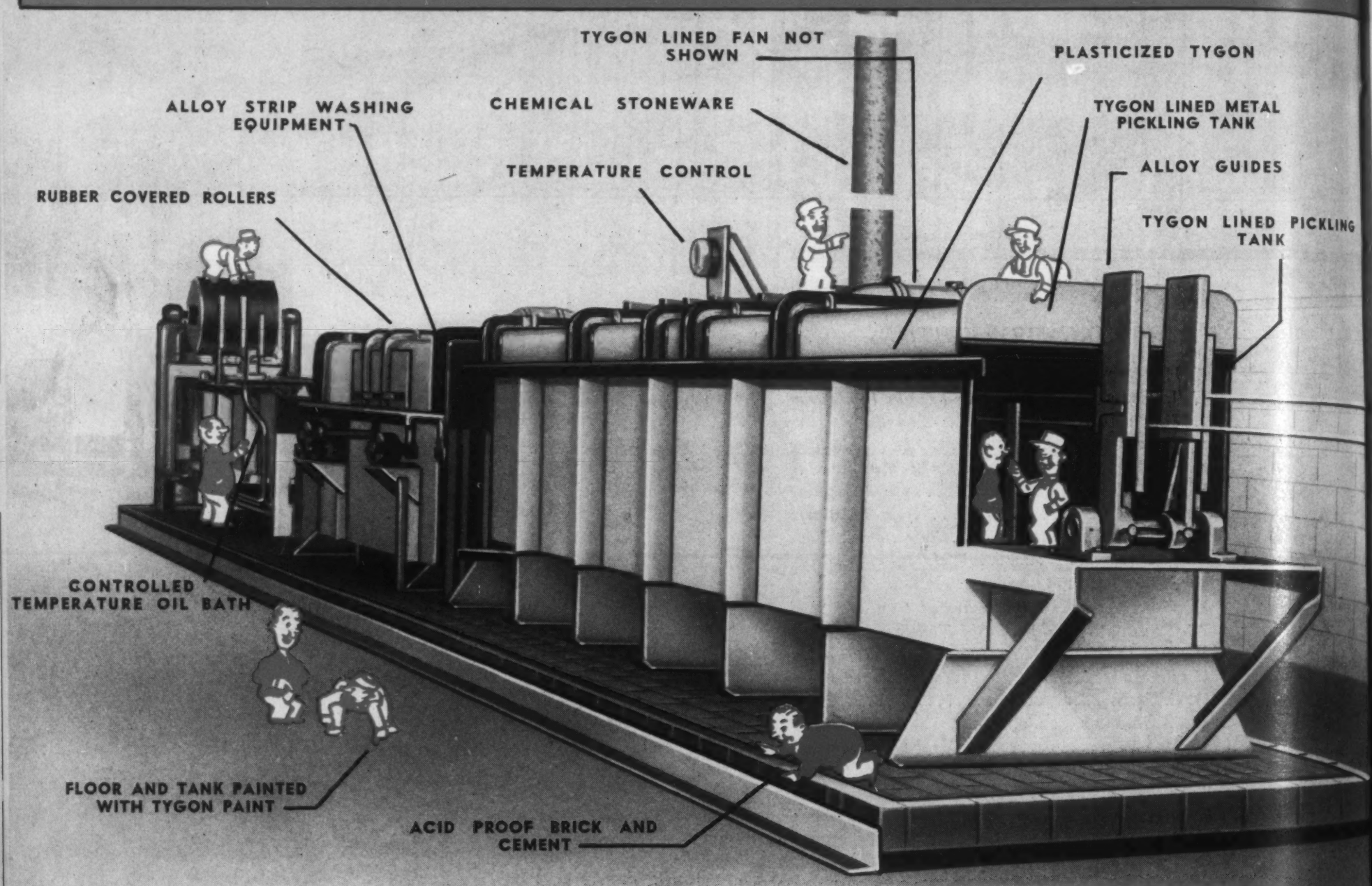

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Casting Chills

"Foundry Problems." Ben Hird. *Foundry Trade J.*, Vol. 63, Nov. 28, 1940, pp. 349-351. Practical.

Three types of castings, chosen from many in which the liberation of occluded gas has caused trouble, are discussed, and a brief detailed description of the method of molding is given.

In the case of a three-way filter pipe, for example, the first difficulty was the lack of facilities for machining the seating. This was overcome by making chills, machined to the correct angle, which were fixed to the core barrel. The chills were lightly coated with linseed oil and plumbago before drying.

No trouble was experienced until 12 castings had been made. When the thirteenth casting was taken from the mold, a large area at the top of the filter was found to be a mere shell. Occluded gas given off from the chills was definitely shown to have caused this trouble. Thereafter, chills were scrapped after the fourth use.

Other examples are also given to prove that chills may cause troubles. In one experiment the gas from the molten metal was collected in large quantities and its analysis corresponded with that given off from the chills. The conclusion was drawn that the volume of chill or insert relative to that of the surrounding molten metal controls the time and amount of gas given off by the chills, and its effect on the casting.

It has been found in practice that it is an advantage to put vent holes in chills where possible. Moreover, where chills are almost surrounded by the molten metal, the chill should be used once only—this has now become general practice. AIK (1)

1a. Ferrous

"Ferrosilicon" from Blast Furnaces

"Manufacture of Ferro-Silicon in the Blast Furnace." *Foundry Trade J.*, Vol. 63, Oct. 31, 1940, p. 284. Descriptive review.

Over the past decade Russian investigators have devoted much attention to the manufacture of ferrosilicon in the blast furnace, and experiments have been con-

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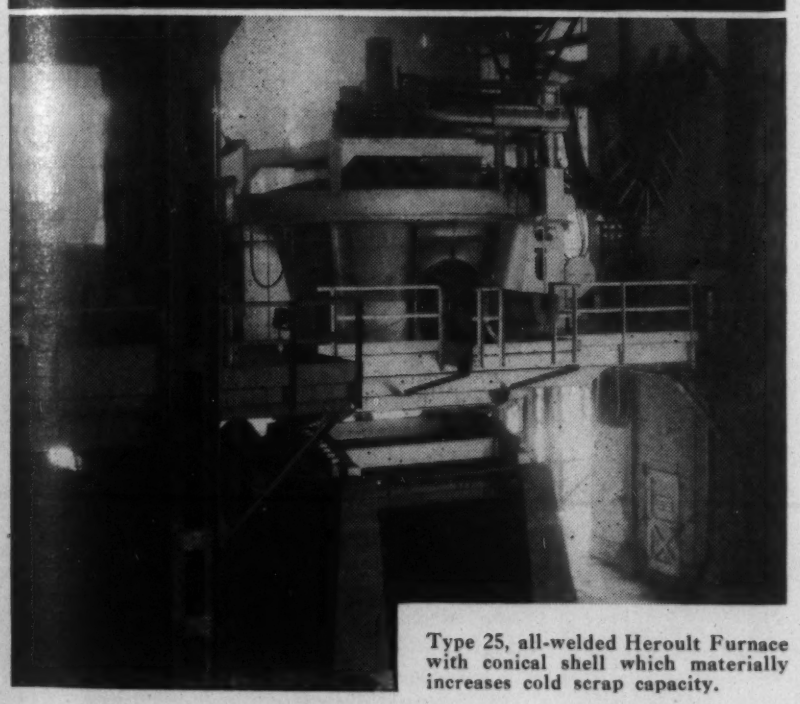

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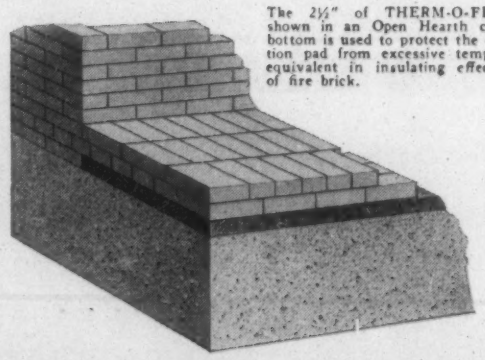

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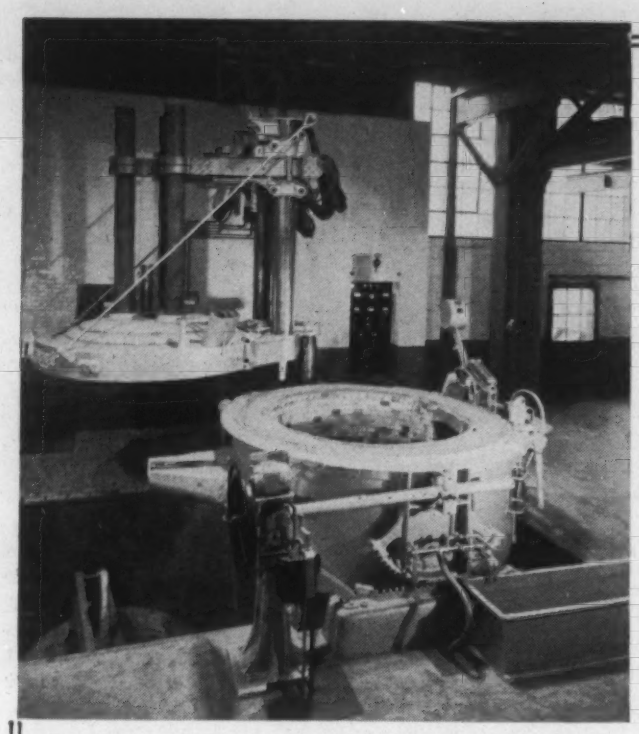

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ducted on varying scales and at different steel works, as surveyed in a recent article in *Stahl und Eisen*. One of these experiments was as follows:

Before changing over to ferrosilicon, the furnace was running pig iron (for steelmaking) with 1.17% Si, 2.62 Mn and 0.05 S. At first, the iron ore was replaced by quartz sand and quartzite and the open-hearth slag added, but two days later blast-furnace slag was introduced.

For the production of 1 metric ton (2200 lbs.) of ferrosilicon, the trial charge contained 13.5% siliceous iron ore (43.2% Fe and 36.2% SiO_2), 9.3% open-hearth slag (10.5% Fe and 25.2% SiO_2), 13.4% cinder (51.6% Fe and 27.3 SiO_2), 10% broken castings, 15.2% steel scrap, 5.3% lime, 17% blast-furnace slag (0.7% Fe, 37.2 SiO_2 and 40.7 CaO), 11.6% coke fines, 4.7% anthracite, and 3100 lbs. of coke, to make up a charge of 7900 lbs. with 1860 lbs. of iron, 1090 lbs. of silica, 300 lbs. of manganese and 665 lbs. of sulphur.

The average through-put at the start of the trial was 69 charges and at the end 76 charges. The ferrosilicon made contained 11.48% Si and 2.60% Mn. The tests appear to show that it is economical to make ferrosilicon in a large blast furnace, although smaller furnaces are certainly better suited to the variable conditions which have to be maintained.

[*This "ferrosilicon" would be termed "silvery pig iron" in American parlance.* —H. W. G.] AIK (1a)

Making Malleable Iron

"Malleable Iron." H. F. Davis. *Can. Metals & Met. Inds.*, Vol. 3, Dec. 1940, pp. 304-307. Practical.

The manufacture of malleable iron is divided into two parts: (1) the production of white iron castings, and (2) annealing these castings to make them into "malleable iron." Two kinds of malleable are produced, "white heart" (made mostly in Europe), and "black heart" (made mostly in America).

In black heart or American malleable there are four ways of making the molten metal: (1) air furnace, (2) cupola, (3) electric furnace, and (4) duplexing. About 75% of Canadian malleable is made in the air furnace. The types of malleable irons include short cycle ferritic; regular cycle ferritic; "railroad" malleable, ferritic; and a few grades of alloy malleable called "high strength," which are spheroidised pearlitic, lamellar pearlitic, and full-annealed ferritic. The latter types are low-silicon irons.

In making up the metal mixture it is well to use at least two grades of pig iron and proportion these as required so that the desired calculated chemical compositions will be secured. The calculated mixture will depend upon the efficiency of the melting practice. Many foundries use steel scrap in the mixture, even as high as 20%.

Common defects of malleable iron are: (1) formation of primary graphite, (2) oxidized metal, (3) too-high or too-low in one or more elements, and (4) metal too cold. Proper control of melting and attention to mixture used will prevent their occurrence. Defects traceable to casting and molding practice may originate with (1) wet sand, (2) improper gating, risering, and applications of chills resulting in cracks and shrinks, (3) too early shake-out with possibility of white-iron cracks caused by strain in sudden cooling, and (4) knocking castings from the gates.

In gray iron, the carbon separates out

as primary graphite, and its form is determined by its crystallization habit. In annealing white iron, the carbon separates as secondary graphite or temper carbon, these crystals having their outer form imposed upon them by external conditions. The successive steps of graphitization are solution of cementite in iron, migration of carbon, and crystallization, ending up in the characteristic malleable structure—a ferritic matrix through which are scattered the temper carbon nodules.

WHB (1a)

Ingot Molds for Steelmaking

A Composite

Among the most complicated of matters in the whole realm of metallurgical engineering is the subject of ingot molds. Entirely apart from the effects of mold composition, shape and dimensions on ingot quality, the steelmaking engineer and mold-making foundryman are both concerned with the "life" of ingot molds, which is affected by such things as ingot mold coatings, pouring temperature, pouring time, mold specifications and structure, and even the weather.

Ingot Quality

In any process where a large number of factors play a part, examination by statistical methods is often the quickest way of isolating individual effects. N. H. BACON ("Metallurgical Observer," *Foundry Trade J.*, Vol. 63, Nov. 21, 1940, p. 339; Nov. 28, 1940, pp. 352-354) reported his experience with such methods applied to problems of ingot quality and mold life. It had been the practice in the case of a certain class of alloy steel to turn the octagon ingot in the lathe until all trace of corner segregation was removed; this was checked by sulphur printing as turning proceeded.

Systematic recording revealed several interesting features: The condition was found to be confined to 1, 2 or 3 adjacent corners. These corners were always on the side of the ingot next to its neighbor, the molds being set in pairs. Some improvement resulted from wider spacing of the molds. A reduction in teeming speed gave much less corner segregation, but trouble then arose from sand inclusions.

The effect of mold thickness and other dimensional factors on heat distribution between ingot and mold and on solidification was studied by T. F. Russell ("The Thermal Relations between Ingot and Mold," Iron & Steel Inst., Adv. Copy, May 1941 meeting, 29 pp.). Circular and square ingots of the same cross-sectional area were cast into molds of 4 different thicknesses, and the effect of mold ratio on the temperature cycle in the ingot near the mold wall, and on the time taken for the center of an ingot to solidify were determined.

Solidification is accelerated by increasing the mold thickness until the "mold ratio" is 0.8-1.0, but further increase in mold thickness has little effect. The greatest difference between mathematical theory and practical observation is found at positions in the mold near the inner face. This is attributed to the effect of the air gap formed between the ingot and mold.

Mold Life

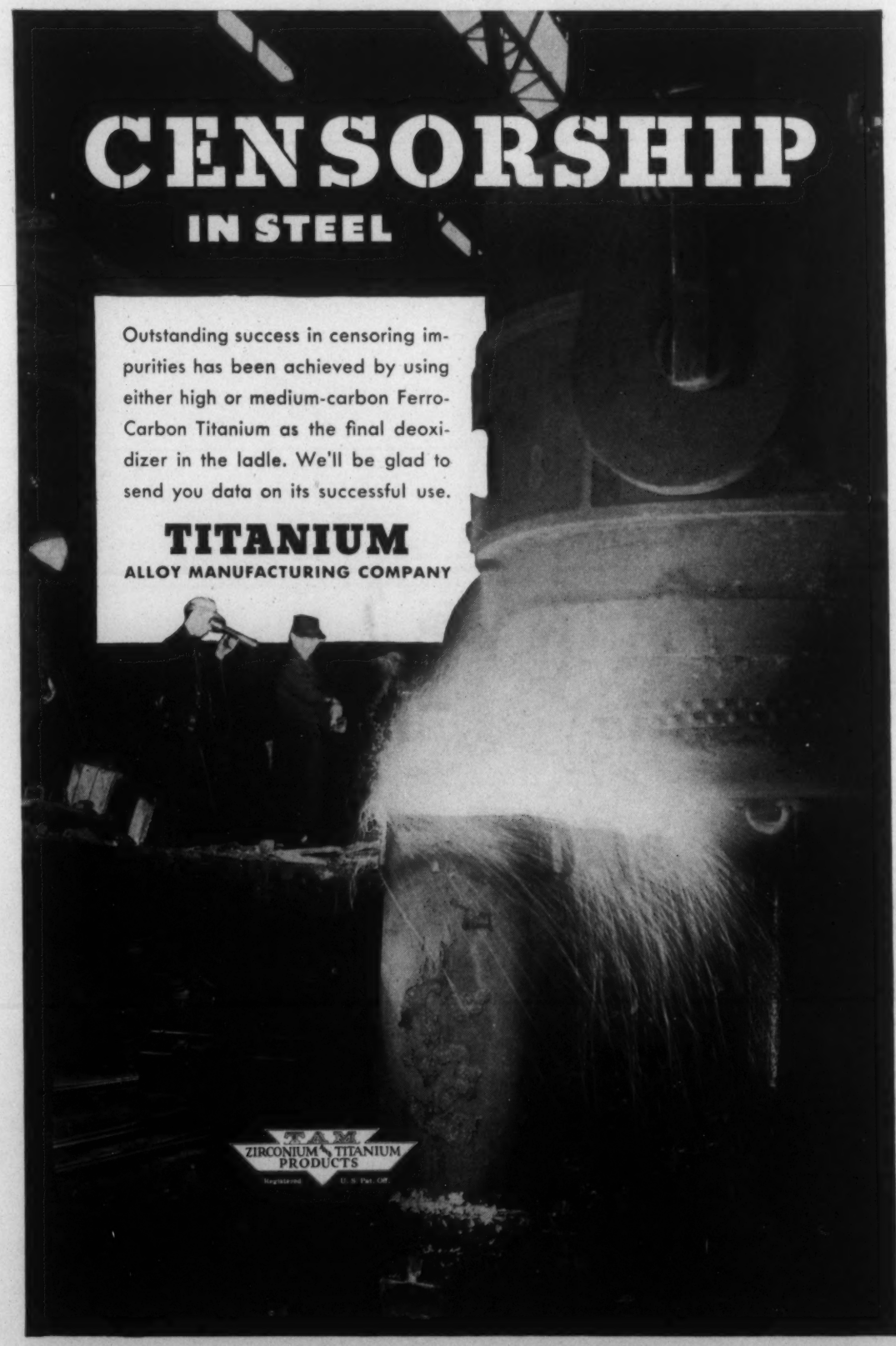
The contour of the octagon mold was also of great importance. All the molds are now made with deeper "inverts": For a 24-in. octagon mold, the radius of face curvature is 12 in.; with a 28-in. octagon, the radius is 14 in.; with a 54-in. octagon, the radius is 27 in., and so on.

Silicon content of the mold, reports BACON, has an important bearing on mold life. Silicon in molds has gradually been reduced from 1.8-2.2%, at which it had stood for many years, to about 1.0%; 0.8% has been found to be a desirable lower limit advisable, since below this the life falls off. Phosphorus also has an important influence on the mold life, but its effects had, up to recently, been obscured by the large variation in the silicon content.

An extensive review and discussion of ingot mold life is given by K. KNEHANS & N. BERNDT ("Ueber die Haltbarkeit von Blockformen," *Tech. Mitt. Krupp, Tech. Ber.*, Vol. 8, No. 4, Oct. 1940, pp. 71-76). According to the literature, composition and microstructure are of foremost importance. The authors find, however, that they cannot be separated from such other factors as cooling time, rate of cooling, general treatment of the molds, pouring methods and so on.

It does seem to be true, however, that an increase of manganese in the mold over 0.8% improves durability, expressed in the number of ingots obtained from one mold before it has to be scrapped. Molds with 1.0% Mn are good for 89 ingots, as compared with 78 ingots for molds with 0.8% Mn. The optimum of phosphorus content seems to be 0.3%, and sulphur higher than 0.1% is considered harmful.

With regard to alloyed molds, the use of vanadium-titanium pig iron for molds with 4% C, 2-2.1% Si is desirable. Molybdenum, tungsten and nickel in molds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are considered to be without effect. Chromium is favorable for long life from 0.78% up, but some operators limit chromium to 0.5% while allowing 0.3% Mo.

In general, a long cooling time of the mold after one pouring and before the next is believed to promote long life. Low temperature of the outside air has a favorable effect; mold durability in winter was found to be 10% higher than in the summer months. Standing time before stripping should be shortened as much as possible; for example, by shortening stripping time from 90 to 40 min., mold durability was increased from 68.8 to 83.3 ingots. Molds used for lower-carbon steels lasted longer than those used for higher-carbon materials. X (1a)

Hot Working of Killed Steels

"Influence of Chemical Composition on the Hot-Working Properties and Surface Characteristics of Killed Steels." Gilbert Soler (Timken Roller Bearing Co.) *Metals Tech.*, Vol. 7, Dec. 1940, 19 pp. Practical.

Under conditions of standard mill practice, each analysis of steel is susceptible to certain types of defects. Mill practice must be varied to obtain the best combination of surface and internal quality in the product. Some of the many factors governing the behavior of alloy steels in rolling and the causes of defects in such steels are discussed, and a number of typical defects are shown.

Chemical composition influences the cast structure and crystallization characteristics of the ingot. It also determines the rate of heating and cooling, the plastic hot-working range, and the phase structure of steel at various temperatures, as well as the tendency to scale formation and decarburization.

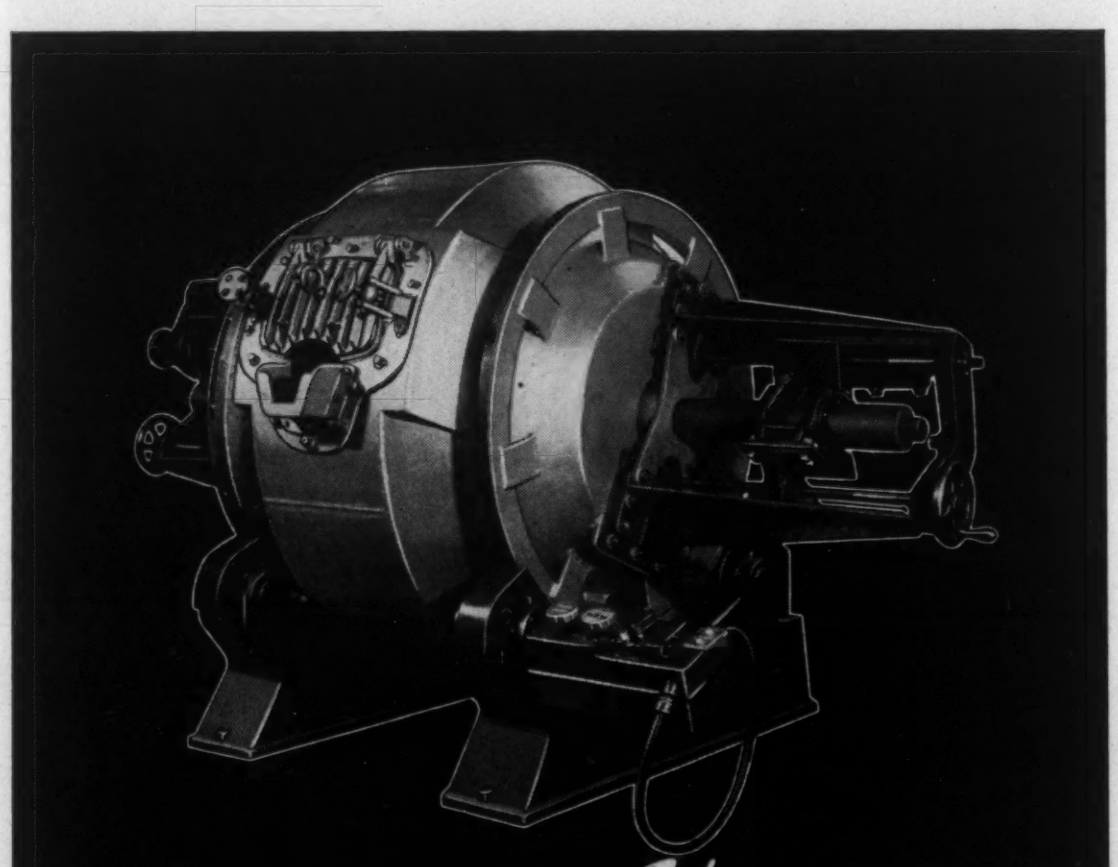
The degree of deoxidation is one of the most important factors in influencing the hot-working properties and resulting surface. The degree of deoxidation affects the density of the cast structure and broadly classifies the steel as killed, semi-killed, or rimming. This in turn manifests itself in surface characteristics.

The manner and extent of deoxidation also controls the amount, type and distribution of nonmetallic inclusions formed. The equilibrium of manganese, silicon and aluminum with the slags and pouring refractories with which the metal comes in contact is important, especially in regard to inclusions of fire-clay origin. Some surface seams and hot-working difficulties can be traced to nonmetallic inclusions.

Low-melting constituents may make hot-working difficult or even impossible. The upper limits of hot-working temperature are determined by the temperature at which fusible constituents will melt and penetrate into the grain boundaries and leave voids between the grains. Fused material at the grain boundaries may cause separation of the grains when steel is hot-worked.

Certain elements may produce hot-shortness or cause surface defects in steel. Sulphur, tin, arsenic, antimony and boron will produce hot-shortness; the degree may vary with the carbon content of the steel and the presence of other elements. If such elements are present in undesirable amounts, the hot-working range is narrowed to such a degree that often the steel cannot be hot-worked satisfactorily.

Soaking-pit drawing temperatures for most of the common alloy steels are presented in a diagram, which shows the general range to be 2250-2350° F. for carbon and alloys steels with less than 0.25% C, 2250-2300° F. for steels with 0.25-0.50% C, and 2150-2250° for steels with 0.75-1.0% C. Thermal conductivity and hardening characteristics are other important factors influencing hot-working characteristics. JLG (1a)



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1b. Non-Ferrous

Inverse Segregation

"Some Practical Observations on Inverse Segregation." Daniel R. Hull (Am. Brass Co.) *Metals Tech.*, Vol. 8, Feb. 1941, 7 pp. Plant investigation.

Certain brass mill observations on inverse segregation are recorded, which in general confirm the gas-pressure theory propounded by Genders in 1926. However, there is one type of inverse segregation that can be accounted for by considering the volatility of a single alloy constituent.

Ordinary brass, for example, is subject to a zinc enrichment of a few tenths of a per cent at the surface of a chill casting. A simple explanation is that zinc vapor from molten metal during pouring is trapped in the space between the mold and the contracted outer solid shell at the bottom of the bar, and then condenses on the clean skin of the freshly-cast brass, to be quickly reabsorbed in its surface.

The practice of throwing some "black lead" in the mold (supposed to float up with the metal and give a smooth, easily-withdrawn casting) led to the observation that enough "black lead" stayed near the

bottom to smother and envelop the zinc vapor there, and cause it to condense in discrete drops that could not be reabsorbed. When black lead is continually added during the pour, enormous quantities of zinc are condensed, and clear to the top of the billet—a clear demonstration that enough zinc vapor *can* be trapped between metal and mold to accomplish the surface enrichment observed.

The absence of lead enrichment in brass surfaces that show normal zinc enrichment is common, but not universal; yellow brasses seldom give evidence of gas, but they are not *immune*. The richer copper-zinc alloys may be made to spew by simple overheating and pouring into oiled molds. Leaded alloys of more than 80% Cu will spew in the mold with moderate overheating under charcoal. The exudations from all such alloys are rich in tin or lead.

The lead enrichment is found in surface protuberances, or spikes (evidence of gas evolution) and the zinc enrichment at the surface is greater than in normal brass. Brass tube castings (67% Cu, 0.50 Pb, remainder zinc) are particularly liable to lead exudation in minor protuberances. If, however, the alloy is poured into a mold without any oil dressing, such spiky protuberances are absent, and no lead enrichment can be found in the surface. Mold oil may thus contribute to gassing, or accentuate the effect of any gas in a metal.

In another example cited, an alloy of 70% Cu, 29 Pb and 1 Ni melted in a high-frequency induction furnace under charcoal and poured into an oiled mold yielded bars the entire surfaces of which were sheathed with lead. If, however, the copper and nickel were first melted and well oxidized, the lead then added and the whole deoxidized with phosphorus and poured into a mold coated only with dry carbon, there was never any lead on the surface, the distribution of this element being uniform throughout the bar. "If gas is not the sole cause of lead segregation, the author has not observed any evidence to the contrary."

Likewise, inverse segregation in tin bronze is attributed to gas pressure. Careful analyses of thin scrapings from the very surface of 8% Sn bronze ingots showed the surface scrapings actually to contain over 20% Sn. While this is typical of bronze melted and poured under reducing conditions, the rich surface layer does not occur after the use of an oxidizing atmosphere. FPP (1b)

Extruding Aluminum Alloys

"Aluminum Alloy Extrusion." Ernest V. Pannell. *Iron Age*, Vol. 146, Nov. 28, 1940, pp. 27-30; Dec. 5, 1940, pp. 40-43, 92. Descriptive.

The extrusion technique used in Europe and described in this article is claimed to be more highly developed than in the United States. Extrusion is cheaper than rolling or drawing because the product may be produced by one pass through the die. The disadvantage is that the part is less thoroughly worked since it is pressed through the die practically at the annealing temperature. The process is thus most valuable for alloy parts that are to be heat treated. Progress in the last 30 yrs. includes increases in press capacity from 500 to 6,000 tons and in the weights of billets from 100 to 1,200 lbs. Pressures are from 50,000 to 100,000 lbs./in.^{2}

In extrusion, the metal is always in the solid or semi-plastic form and the laws of fluid pressure do not apply. As the plunger moves forward, the hot metal tends to move before it and the part opposite the die is sheared off and extruded. At the same time, the metal feeds in radially to the center just in front of the moving pressure pad and this action continues up to the end of the stroke.

In the case of aluminum alloys, the skin of oxide surrounding the billet is important. The friction of this skin on the container wall is high and if the correct clearance is used on the following pad, the latter will shear the metal just inside the skin leaving it as the "skull" in the bore. If the pad approximates to fit, the container skin will buckle and turn over at the rear and will extrude with the last portion of the rod and may make it unsound. The effect is to produce a thin tube of oxide surrounding a core of solid metal, which latter may be pushed out of the rod.

The following precautions are employed to overcome this defect: reasonable degree of reduction, of 8:1 or more; (2) use of clean billets, carefully poured and fed; (3) ample clearance of the pressure pad; and (4) where possible, the use of a multiple die to decentralize the product. Temperature of extrusion varies according to the metal pressed. Aluminum can be worked fast over a wide range of temperature, but is usually processed at 850°-920° F. Metals of the Duralumin and Hiduminium class are worked at 720°-780° F., using 50,000-60,000 lbs./in.^{2} pressure.

The direct process described above is

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claimed to be wasteful of energy and yields an imperfect product. In the "inverted" process, a die mounted on a hollow plunger is pressed into the billet; the metal is in motion only at the die opening and there is no disturbance of the oxide skin, and the central core of the rod is sound. The process also gives a higher metal yield, since the only discard from the billet is the thin shell around the bore of the container. However, mounting of the die on the hollow plunger has its problems. Not only is it difficult to obtain a rigid mounting, but the size of the rod to be extruded is limited by wall thickness of the plunger.

Extrusion of tubes involves the use of a core or mandrel to form the bore. The usual method employs a separate plunger and mandrel operating through the center of the container right up to the die opening. One British authority (A. WRAGG) quotes the following tolerances on tubes produced on a horizontal press: up to 1½ in. outside diameter an eccentricity of 0.01 in.; up to 2 in. an eccentricity of 0.015 in.; and up to 3 in. an eccentricity of 0.02 in. On the overall diameter a tolerance of 0.003 in. is usual for tubes up to 3 in. diam., and 0.005 in. for larger diameters.

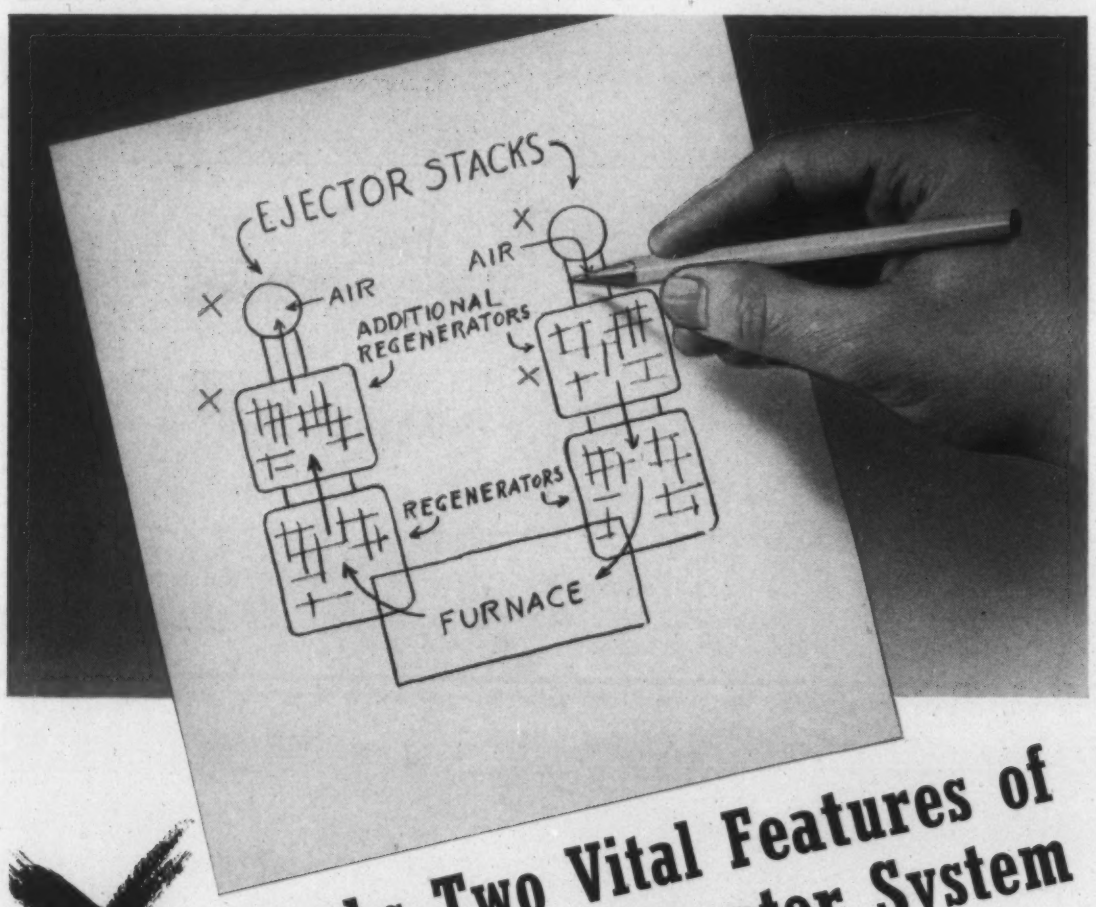
Several processes are available for producing closed sections without the use of a mandrel, and are applicable to tubes and box sections. While the core or plug cannot be introduced in a simple die, it can be done if the die is in two parts. Thus, the first part will be in the form of a "C" in which the core of steel is supported by a tongue of metal at the side. This core is extended beyond the face of the die through a counterpart having a round opening forming an "O." Under the correct temperature and pressure, the metal welds together on passing the tongue and a perfect tube is formed.

In some designs, the die opening begins as 4 circular holes equally spaced around a central axis. These open out and join around the central core having a sharply defined edge, to form the bore of the tube. The outer wall is formed by a similarly-defined flange in the outer die, which registers with that on the core.

The aluminum alloys usually extruded are pure (99%) aluminum, normal alloys and heat-treated alloys. Aluminum of 99% purity is important in architectural and auto body moldings, tubes and a wide range of sections that do not need mechanical strength. The normal aluminum-copper, aluminum-zinc and aluminum-silicon alloys give a product 3-4 times stronger than the pure metal. Higher pressures and closer working temperatures are used. Extrusion of the aluminum-copper group, for example, is done at 660° F. and pressures of 29,000-33,000 lbs./in.² and the finished rods have a tensile strength of 26,000-29,000 lbs./in.² with 11-6% elongation.

Duralumin and Hiduminium type alloys are the most important aluminum extrusion alloys. All extruded material is reheated and quenched after it comes from the press, and is thereafter aged or precipitation treated. After final treatment, these alloys average 60,000 lbs./in.² tensile strength with 15% elongation. An alloy devised specially for the extrusion of high-tensile rod and tube is known as RR 77. It is an aluminum-copper-zinc-magnesium alloy containing some nickel and titanium, with 90% Al. The final tensile strength of this extruded and aged alloy is 75,000 lbs./in.²

VSP (1b)



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Oxygen in Copper

"SOLUBILITY OF OXYGEN IN HIGH-PURITY COPPER." ARTHUR PHILLIPS & E. N. SKINNER (Yale Univ.) *Metals Tech.*, Vol. 8, Jan. 1941, 8 pp. Research.

Because of a study on hydrogen embrittlement of copper it was found desirable to know the solid solubility of oxygen in copper of high purity. Some oxygen-free high-conductivity copper was obtained and rolled to a thickness of 0.1 in. Pieces of this were heated in air to different temperatures, and then for long periods in nitrogen at the same temperatures. This was done to saturate the copper with oxygen at the temperatures studied.

When all of the heating was done in air, too much of the metal scaled away. After supposedly saturating with oxygen at the desired temperature, the scale was removed by dipping in nitric acid. Chips were then analyzed for oxygen by heating in pure hydrogen and determining weight loss.

The solubility of oxygen at temperatures below 1475° F. was approximately 0.002%. The solubility at all temperatures was appreciably below that reported by Rhines and Mathewson. Work was done on very pure copper and the same values obtained as for OFHC copper. A few analyses made by W. A. Baker of the British Non-ferrous Research Assoc. were in good agreement with analyses made by the authors. Inadequacy of methods of analysis for oxygen and other elements found in very small amounts in copper is pointed out.

JLG (1b)

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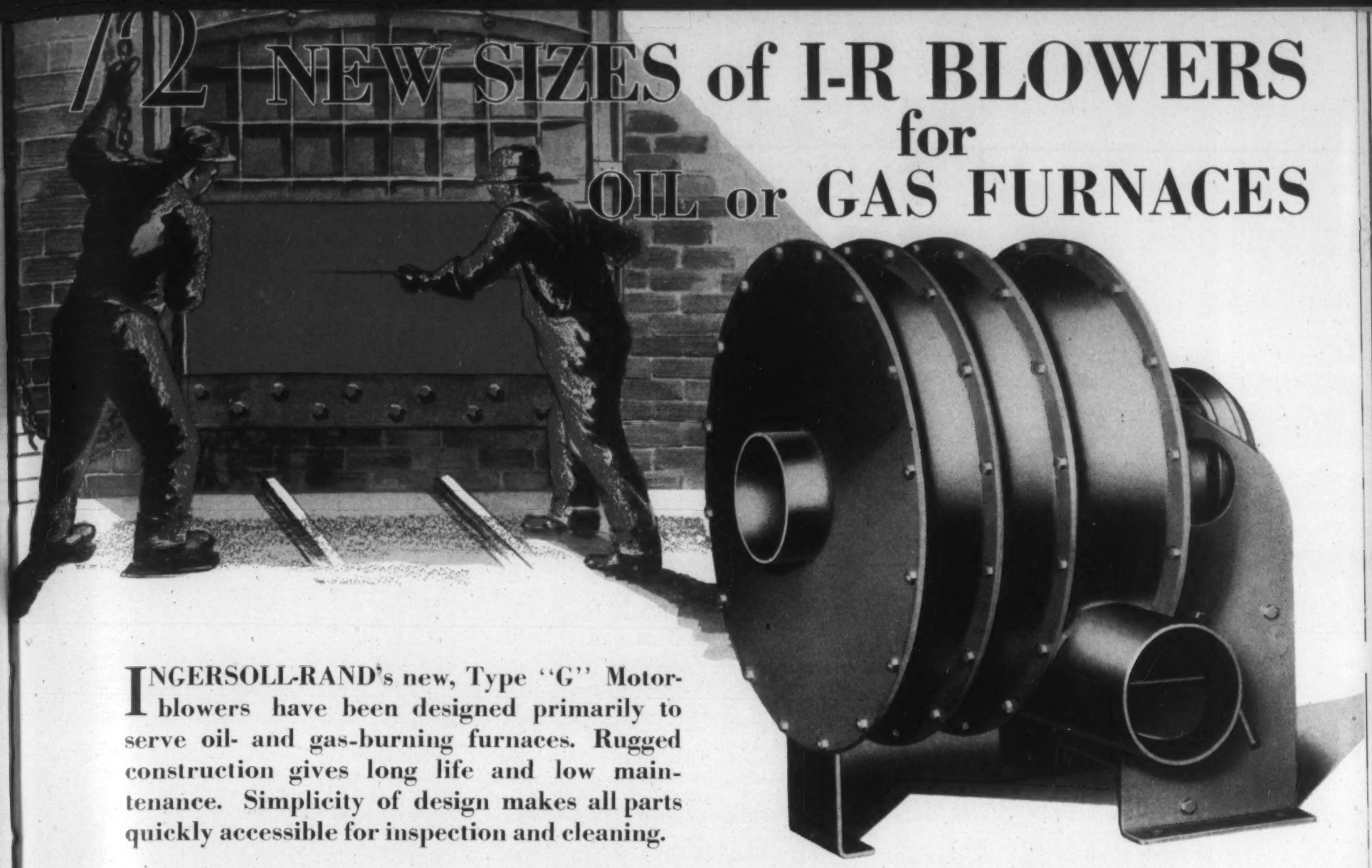

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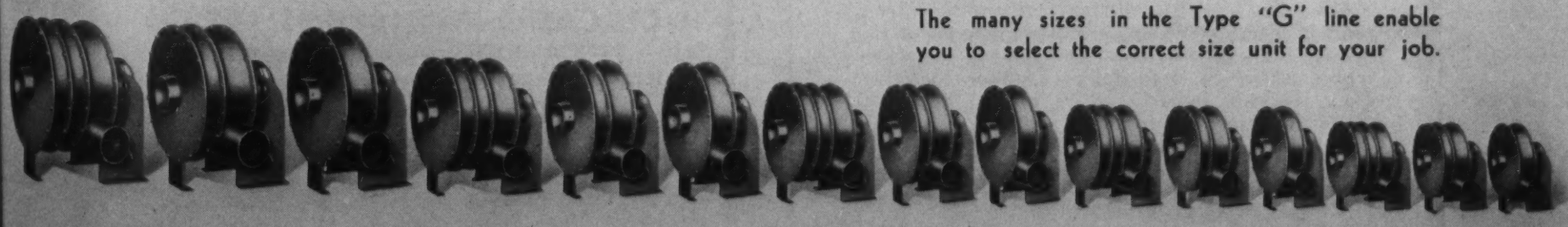

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Welding With the "Arc Torch"

"The Arc Torch—a Widely Adaptable Heat Source." Frank W. Scott (Univ. Minn.) *Steel*, Vol. 107, Dec. 23, 1940, pp. 42-46. Practical.

By means of the arc torch, an electric arc is steadily maintained between 2 carbon electrodes held at an angle to each other, with the arc flame deflected below the ends of the carbons. The "flame" thus obtained is extremely hot, easily controlled, steady, and reducing, with no gas pressure behind it to force the metal away from the point of impact.

In welding aluminum and its alloys by the arc torch, distortion is reduced and light gages can be butt-welded without backing. A strip of the base metal may be used as filler material. For parts to be anodized, the lowest possible heat must be used in welding, the weld must cool naturally, and the filler material should have either the same composition as the base metal, or should be a 5% Si aluminum alloy. Most castings can be welded without preheating, except those with hollow sections.

Welding cast-iron with the arc torch will produce sound, dense, machinable welds. The arc flame is slightly carburizing when held close to the metal. The work should be preheated. Metal from a flux-coated cast iron filler rod is used for the joint.

Cast-iron is brazed with good results, using the same materials and procedure adopted for gas welding. For best results, a good grade of low-temperature cast-iron brazing flux and a brazing material such as Tobin bronze should be used. Malleable iron can be brazed with excellent results using standard brazing rods and fluxes. All thicknesses of steel from 30 gage to fairly heavy sections can likewise be brazed.

As there is less tendency toward burning the zinc out of brazing rods with the arc torch than with other methods, extremely strong, ductile metal, free from porosity, pin-holes and blow-holes, is obtained. The brazing metal becomes very fluid and results in a smooth surface with less finishing necessary. Galvanized sheet-steel and pipe can be brazed without destroying the zinc adjacent to the braze, by careful control of the heat and use of coated silicon, bronze or similar brazing rods and a flux. Brass, bronze and nickel alloys can be welded with common brazing flux and strips of parent metal as filler, using the same procedure as when brazing.

The arc flame can be used for applying any of the hard or silver solders on brass,

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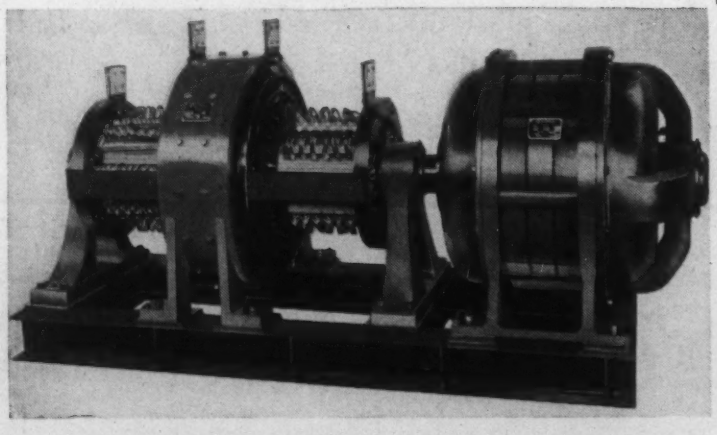

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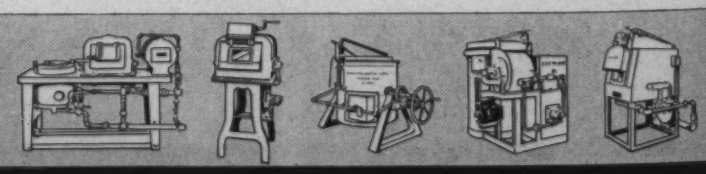

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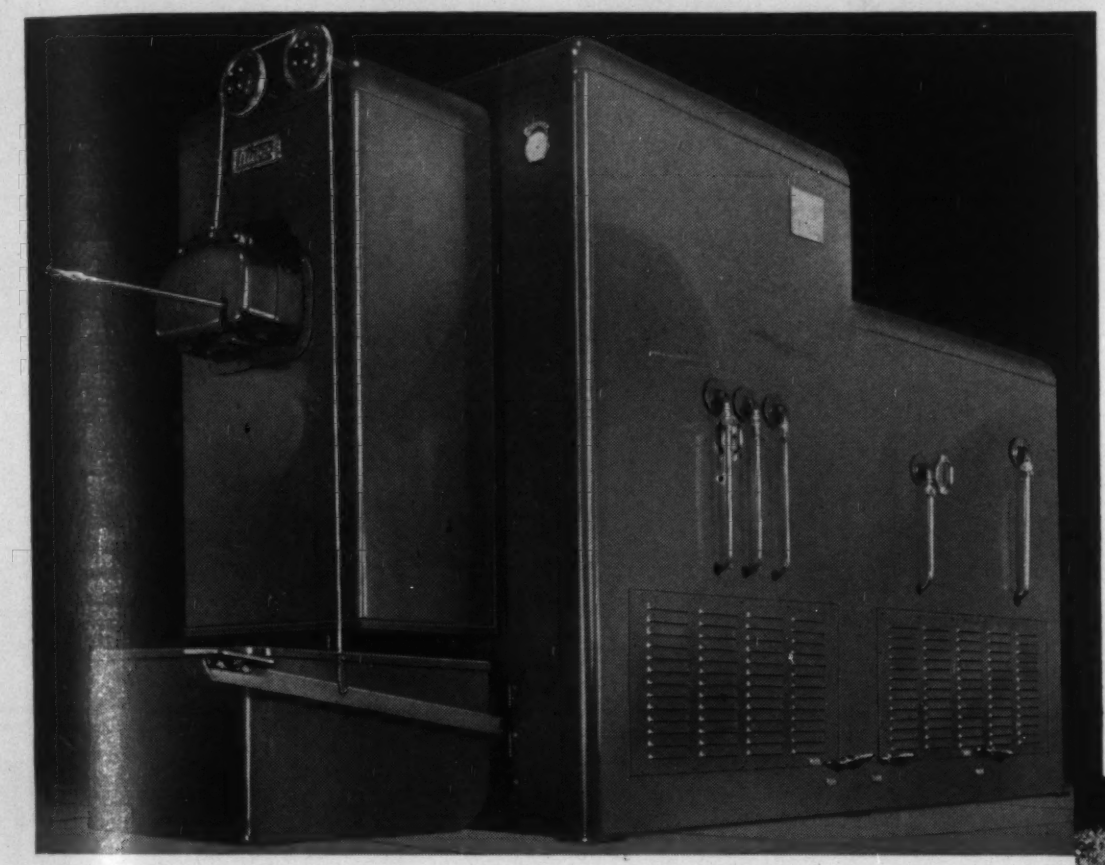

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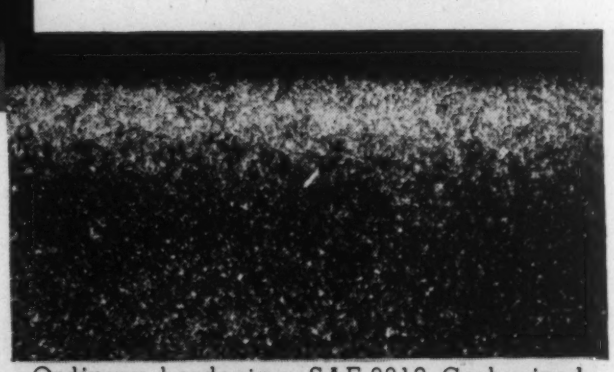
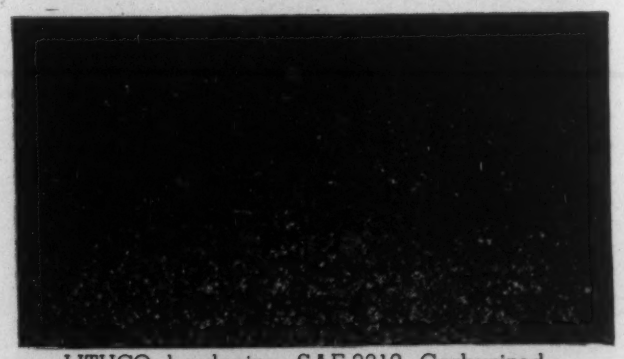


Ordinary hardening, SAE-3312 Carburized, shown in this micrograph, magnification 100X



LITHCO hardening SAE-3312 Carburized—no decarburization, carburization or scaling.

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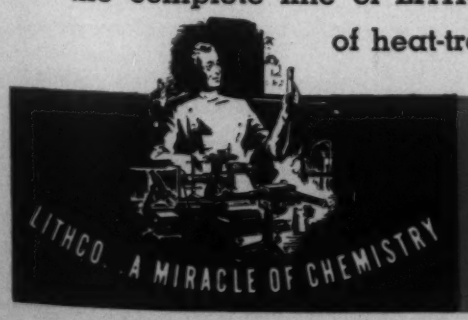

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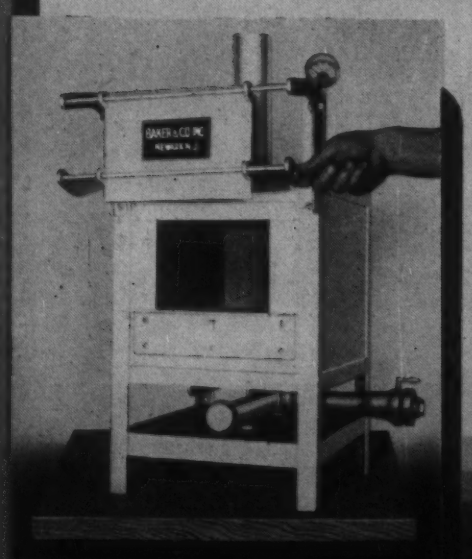

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copper, bronze, or low- or high-carbon steels; for hard surfacing; and for preheating small castings of aluminum, cast-iron, white metal and copper alloys. Soft solders are applied with ¼-in. carbons and currents of 20–35 amps. on copper, brass, galvanized or tinned surfaces.

The cost of the arc torch, including carbons and electric power, will average 15–50 cents/hr. The carbons are specially designed, and have a soft core of chemically treated materials that are responsible for the soft, hot, stable flame. A uniform copper-plated cover improves both the life of electrode (by retarding the oxidation rate in air) and electrical efficiency. With a-c. welders, the carbons used are the same size, as the heat generated is equal at both electrodes; with d-c. welders, the positive terminal generates about 66% of the heat, and special holders and carbons have been designed to compensate for this. MS (2)

Polishing Wheels

"Reducing the Cost of Polishing." H. R. Power. *Machinery, London,* Vol. 57, Oct. 24, 1940, pp. 100-102. Practical.

Wheels are generally made of woolen or cotton for polishing iron, steel, brass, bronze, and aluminum; of canvas for roughing cast iron, steel, or for dry finishing on hardware; of softer canvas for heavy non-ferrous castings; of quilted thin canvas for irregular shapes; of walrus hide for fine finishing of high-carbon steel, firearms, cutlery, and silverware; of sheepskin or felt for fine finishing of irregular shapes.

Hide glue is used for bonding the abrasive to the wheel; the glue should have a viscosity of 115 millipoises or higher. Water-glue ratio is very important. Most wheels are impregnated with artificial alumina; some silicon carbide is used for polishing glass and granite, while rouge or pumice may be used for finishing work. It is important that the abrasive have a uniform grain size and proper-shaped particles.

The glue should be mixed with water and allowed to soak before using. It should never be heated over 160° F. for application as it loses its strength at higher temperatures. Drying of finished wheels is also important; the wheels should be held 48 hrs. at about 80° F. in an atmosphere with 50% relative humidity. JZB (2)

2a. Ferrous

Shell Forging

A Composite

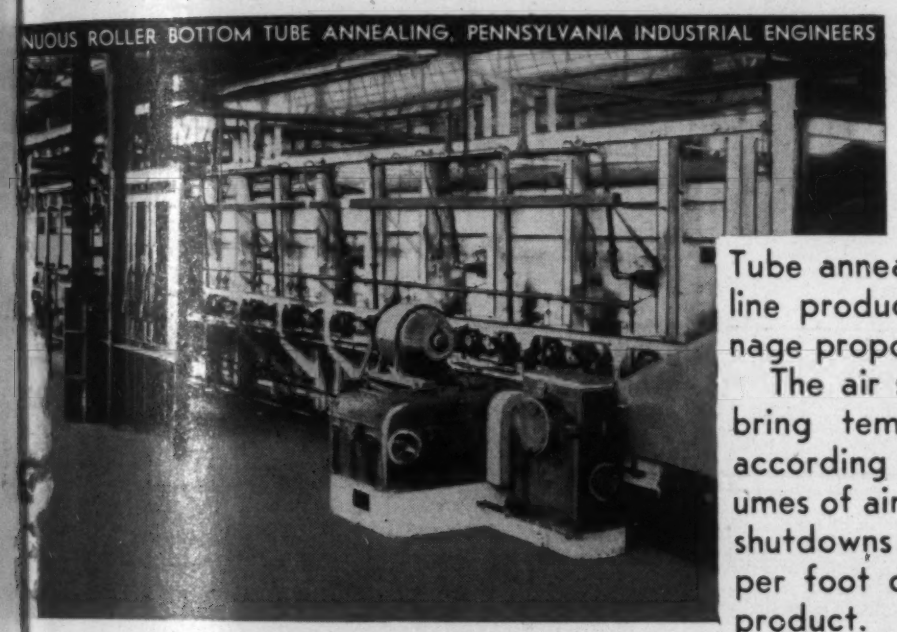
The production of shell forgings has been conventionally carried out in hydraulic presses, starting with either round or square-sectioned billets that were pierced on vertical piercing presses and drawn on horizontal drawing presses. Recently there has been a notable swing toward shell production on mechanical forging and upsetting machines, although some believe the latter to be wasteful of material, to yield a structure inferior to that of the pierced-and-drawn shells, and to offer relatively low production rate.

Hydraulic Presses

The hydraulic shell forging presses are still important, and recent design improvements have increased their utility. Joseph Malborn of United Engineering & Foundry Co. ("Shell Forging," *Heat Treating & Forging,* Vol. 27, Jan. 1941, pp. 18-19)

TUBE ANNEALING

CONTINUOUS ROLLER BOTTOM TUBE ANNEALING, PENNSYLVANIA INDUSTRIAL ENGINEERS



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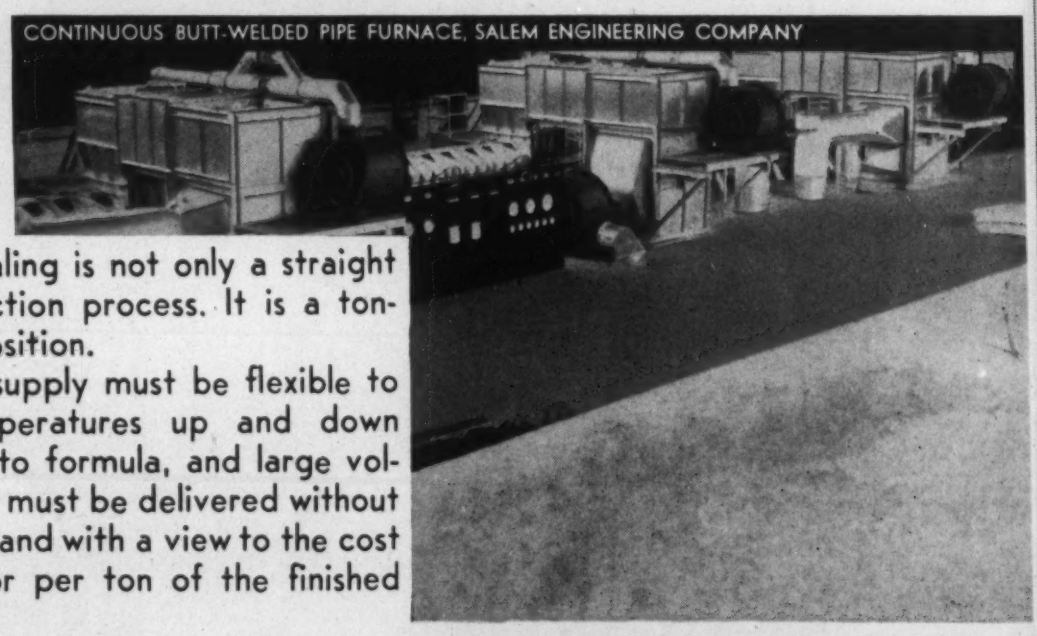


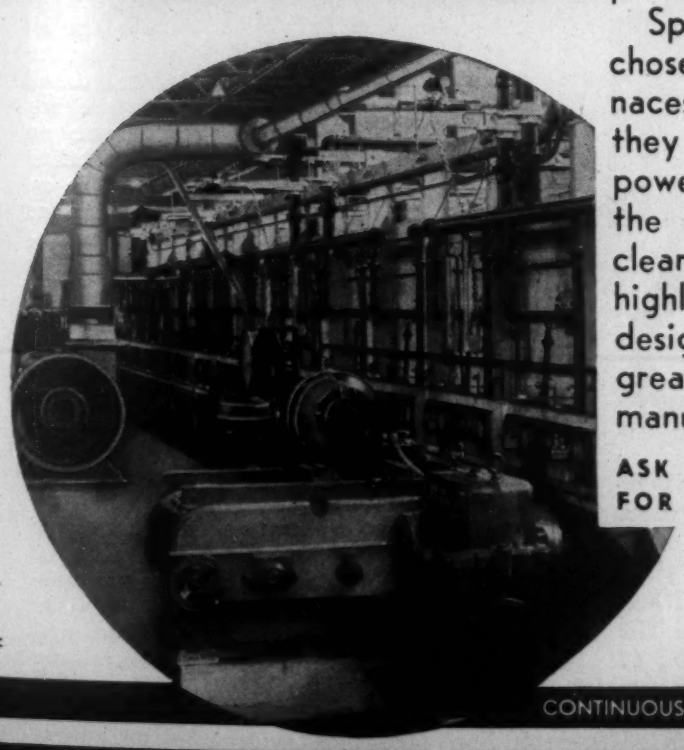
CONTINUOUS BUTT-WELDED PIPE FURNACE, SALEM ENGINEERING COMPANY

Tube annealing is not only a straight line production process. It is a tonnage proposition.

The air supply must be flexible to bring temperatures up and down according to formula, and large volumes of air must be delivered without shutdowns and with a view to the cost per foot or per ton of the finished product.

Spencer Turbo-Compressors were chosen for the Tube Annealing Furnaces shown on this page because they deliver a *constant pressure* with power input in direct proportion to the *volume* of air delivered. Wide clearances, only two bearings, and a highly efficient centrifugal impeller design are other reasons why the great majority of furnace and oven manufacturers prefer Spencer.

ASK YOUR EQUIPMENT MANUFACTURER FOR THE SPENCER TURBO BULLETINS



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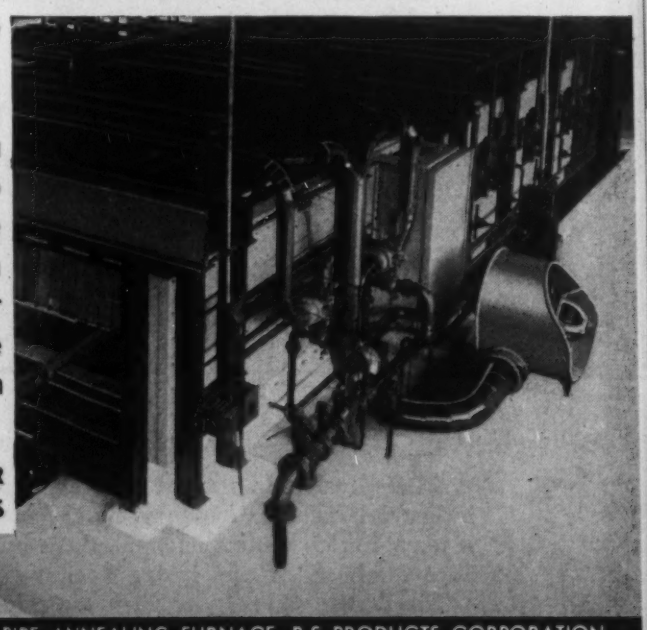

CONTINUOUS CENTRIFUGAL PIPE ANNEALING FURNACE, R-S PRODUCTS CORPORATION

CONTINUOUS ROLLER BOTTOM TUBE ANNEALING, PENNSYLVANIA INDUSTRIAL ENGINEERS

SPENCER TURBO COMPRESSORS

HARTFORD

35 TO 20,000 CU. FT. ⅓ TO 300 H.P. 8 OZ. TO 5 LBS.

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describes a newly-designed hydraulic piercing press that is claimed to provide smoothness of operation, speed, easy accessibility of all working parts, and quick tool changing, and to occupy a minimum of floor space. The press is designed for 75-mm. and 90-mm. shells.

The press is of the single inverted down-traveling pot-type with four punches mounted on a rotating turret. Punches can be changed in a few seconds. Presses designed to give 200 net tons pressure at 2500 lbs./in.^{2} operating pressure, and capable of making 6 operations per minute, with a monthly average production of around 270 75-mm. shells per hr. and 250 90-mm. shells per hr. Larger piercing presses of this type are now available for forging 105-mm. and 155-mm. shells. These presses are followed in use by the usual draw presses. The piercing presses may be used with either round billets or bevel-cornered or round-cornered square billets.

Mechanical Forging Presses

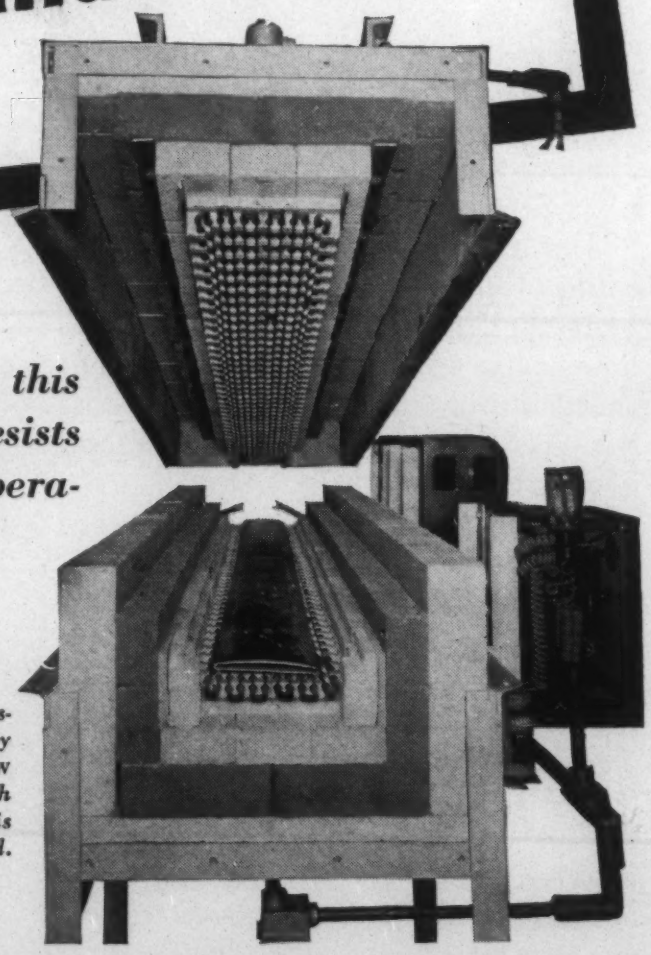
The displacement piercing method of forging artillery shells on an upsetting forging machine is described by W. W. CRILEY of Ajax Mfg. Co. ("Shell Forging by the Upset Method," *Iron Age*, Vol. 147, Jan. 16, 1941, pp. 25-28). In this process the shells have their cavities "forge-finished" to such close tolerance that no internal machining is necessary, and accuracy of concentricity is so high as to reduce considerably the amount of metal machined from the exterior.

Dies and tools are provided with 5 forging positions: buttoning or upsetting the end of the bar to the full o.d. of the finished forging, and then progressively piercing in the second, third, fourth and fifth operations. After the first operation the piercing merely expands the metal to fill the die cavity without further upsetting.

This method is the practice followed at Frankford Arsenal. Originally the forging was done in a 4-in. upsetting machine, but the preference now is to forge in a 5-in. forging machine because of greater die height, rigidity, power and more reserve capacity for sustained production. Such a machine can also forge 90-mm. shells or the 81-mm. trench mortar shell. Bar stock is the raw material, and it is sawed, sheared or nicked and broken to a length sufficient for producing 2 shell forgings. After one shell has been forged the other end of the bar is heated and the first shell serves as a tong-hold while the second shell is being forged. One machine with a crew of 6 or 7 men will produce 65-75 shells of 75-mm. size per hr. on an average.

The newest type of mechanical forging press is known as the Baldwin-Omes mechanical shell forging machine—as described in our February 1941 issue, p. 177. F. G. SCHRANZ of Baldwin-Southwark Div. ("Some Typical Shell Forging Methods", *Steel*, Vol. 108, Jan. 13, 1941, pp. 48-50) gives a detailed description of this press, which features combination piercing and drawing in the same mechanical unit. No machining is required inside the shells, and the new presses are said to be capable of producing more than twice as many forgings per hr. as other types. (2a)

Welded INCONEL withstands 1850° F.



Formed from sheet, this 7" x 1" x 10' tube resists effects of high temperature and controlled atmosphere

Electrically heated, controlled atmosphere heat treating furnace made by H. O. SWOBODA COMPANY, NEW BRIGHTON, PA. *Flat tube through which spring steel stock passes is made of 3/16" Inconel sheet, welded.*

HOW valuable a metal is Inconel for industrial furnaces is shown by the part it plays in this controlled atmosphere furnace for heat treating spring steel stock.

The 7-inch wide, 1-inch high flat tube, 10-feet in length, is formed from 3/16-inch Inconel sheet, joined by welding. Used in temperatures up to 1850° F., it must withstand the effects of furnace atmospheres containing hydrogen, nitrogen, carbon monoxide and other products of combustion.

Full information on Inconel and other high-nickel alloys in Bulletin C-8, "High Temperature Uses of Monel, Nickel and Inconel." Write for this bulletin to: The International Nickel Company, Inc., 67 Wall Street, New York, N. Y.

INCONEL — INCO HIGH-NICKEL CHROME ALLOY — 80—14

Tinned Piston Rings

"TINNED PISTON RINGS." *Foundry Trade J.*, Vol. 63, Nov. 21, 1940, p. 235. Descriptive.

The use of tinned pistons greatly assists in reducing their wear. It was evident that similar advantages ought to result in the case of piston rings, but attempts to produce satisfactory tin coatings on rings were not at first successful. The problem has, however, been solved and a number of firms are now tinning piston rings.

The rings are produced from a special quality cast iron having the desired physical structure and properties. They are ground accurately to size, making allowance for the thickness of the tin. Any grease on the rings is removed in a hot alkaline bath; and the rings are then etched in an acid bath. After this treatment the surface of the rings is free from loose contamination from the grinding operation and to contain small hollows or depressions. The rings are now washed thoroughly and transferred to an electro-tinning bath of the alkaline stannate type and given a coating of 0.0005 in. of pure tin; after which they are washed and dried and are then ready for use.

The pitted structure of the tinned surface has a number of advantages, chief of which is that it assists in retaining the lubricating oil on the ring during the formation of the so-called "Beilby layer." The tin coating is sufficiently plastic to flow under the points of greatest pressure and thus prevents scuffing while the surfaces are "running-in."

The combination of the hard network of iron phosphide with a plastic metal like tin forms a very close resemblance to ordinary bearing metals. Examination shows that the surface of a tinned piston ring is rapidly run in and quickly develops a lubricant-carrying surface without risk of damage to the cylinder. AIK (2a)

Whiten Sez:

"Knowledge and timber shouldn't be much used till they are well seasoned . . . Our welding experience that preceded our manufacturing has done much to sell MAURATH *Electrodes minus a heap of speakin'."*

MAURATH, INC., CLEVELAND

BUILDER OF BETTER WELDING ELECTRODES IN ALL ANALYSES

New Heat Treatment for Magnets

COBALT - NICKEL - ALUMINUM MAGNETS WITH IMPROVED PROPERTIES ("Kobalt-Nickel-Aluminium-Magnete mit Vorzugsrichtung") W. JELLINGHAUS. *Tech. Mitt. Krupp, Forsch. Ber.*, Vol. 3, No. 10, Sept. 1940, pp. 143-145. Research.

A new method has been discovered of increasing still further the magnetic flux capacity of the already highly magnetizable iron-nickel-cobalt-aluminum-copper permanent magnet alloys. If the magnets are heated to high temperatures and then cooled in a strong magnetic field, their remanence is appreciably higher than when cooled in the absence of a magnetic field. The flux capacity $(B \times H)_{max.}$ is much higher, as is also the area of the magnetization loop.

A magnet alloy with 20% Ni, 15 Co, 9 Al and 4 Cu had its magnetic properties affected by the treatment as indicated in the upper table.

Another alloy with 15% Ni, 25 Co, 9 Al and 3 Cu was improved as indicated by the data in the lower table.

The composition of magnet steels susceptible to this special magnetic treatment during cooling is in general 13-17% Ni, 22-26 Co, 7-9 Al, 3-6 Cu. Copper-free alloys, however, give only slightly less favorable results. Iron-cobalt-nickel-aluminum alloys containing titanium can reach flux capacities of 3×10^6 by cooling in a magnetic field, although steels with *high* titanium content are less suitable for such treatment. Ha (2a)

Property	Cooled conventionally		Cooled in magnetic field	
	as-cooled	tempered	as-cooled	tempered
B_r, gauss	7000	6880	7950	8110
H_c, oersted	632	658	608	653
$B_r \times H_c$	4420×10^3	4520×10^3	4830×10^3	5300×10^3
$(B \times H)_{max.}$	1.56×10^6	1.62×10^6	1.91×10^6	2.06×10^6
$(B \times H)_{max.}/B_r \times H_c$	38%	36%	40%	39%

Property	Cooled conventionally		Cooled in magnetic field	
	as-cooled	tempered	as-cooled	tempered
B_r, gauss	9760	7970	12900	12250
H_c, oersted	266	456	263	597
$B_r \times H_c$	2600×10^3	3880×10^3	3400×10^3	7320×10^3
$(B \times H)_{max.}$	1.29×10^6	1.33×10^6	2.4×10^6	4.5×10^6
$(B \times H)_{max.}/B_r \times H_c$	49%	34%	71%	61%

FOR BETTER WORK AT LOWER COST
a.c.f. BERWICK ELECTRIC METAL HEATERS

BETTER WORK. Electric heating causes less scale; hence, less injury to dies, better finish with less grinding and polishing. Heats uniformly across the diameter; hence, no hard cores to split dies. Metal flow is evenly spaced in upsets. Electric Eye holds exact, uniform heats—especially important with alloy steels.

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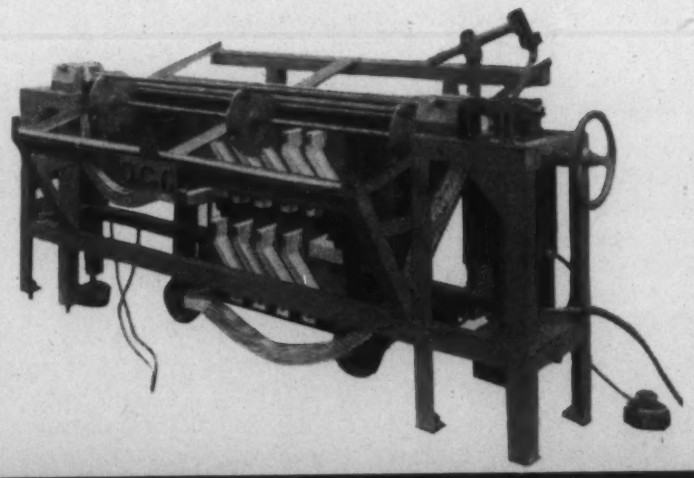
● The a.c.f. air-operated Electric Bar Heater heats bars six feet long and from ⅜" to 1" in diameter to 2000°F. in from 30 to 75 seconds. Bar heaters can be built for longer or shorter stock to your specifications, and your inquiries are invited. Other types of a.c.f. Berwick Electric Metal Heaters are available; rivet heaters, horizontal normalizing and hardening heaters, forging heaters, air-operated heaters, and fully automatic heaters. Electric Eye controls opening of electrodes. Twelve heat speeds give proper range of heats.



AMERICAN CAR AND FOUNDRY COMPANY
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Gas-Welding Aircraft Steels

THE IMPORTANCE OF THE COMPOSITION OF THE WELDING GAS AS AFFECTING THE WELD-CRACKING OF STRUCTURAL STEELS FOR AIRCRAFT ("Bedeutung des Schweissgases und seiner Zusammensetzung für die Schweissrissigkeit von Flugzeugbaustählen") J. MÜLLER. *Autogene Metallbearbeit*, Vol. 33, Nov. 15, 1940, pp. 277-281. Experimental.

Heretofore attempts to explain the oft-observed welding cracks in steels used in the construction of aircraft have not been conclusive. Because the purity or composition of the welding gas may be a contributing factor, a series of experiments was made extending over several years in which fusion welding with bottled acetylene gas was used, to which various amounts of hydrogen sulphide and phosphine (common impurities in acetylene) were added, singly and together.

For hydrogen sulphide additions alone, up to 0.8% seemed to have no effect on the weld-cracking, but above 0.9% H_2S had a decidedly harmful effect on the plain carbon and on chromium-molybdenum steels used in the tests. Additions of phosphine alone up to 0.12% had practically no effect, but hydrogen sulphide + phosphine contents totaling over 0.8% also show a decided detrimental effect.

As the amounts of these gases normally present in acetylene, whether bottled or taken directly from an acetylene generator, is within this 0.8% limit, no harmful effect can be anticipated. It is, however, recommended to use a gas of the highest possible purity, as weld-cracking decreases with increasing purity of the gas. [*The direct and indirect influence of hydrogen on the weld cracking of steels has been exhaustively reviewed by Zapffe & Sims —see our February 1941 issue, p. 206.* —Editors.] Ha (2a)

Strains in Induction Hardening

"INNER RESIDUAL STRAINS IN STEELS, PRODUCED BY HIGH-FREQUENCY SURFACE HARDENING." I. E. KONTOROVICH & L. S. LIVSHITS. *Metallurg*, Vol. 15, Aug. 1940, pp. 30-37. In Russian. Experimental.

The effects of the conditions of high-frequency surface hardening and the depth of the hardened layer upon the magnitude and distribution of inner residual strains in specimens 2.5 in. long and outside and inside diam. of 2 in. and 1.1 in. were observed.

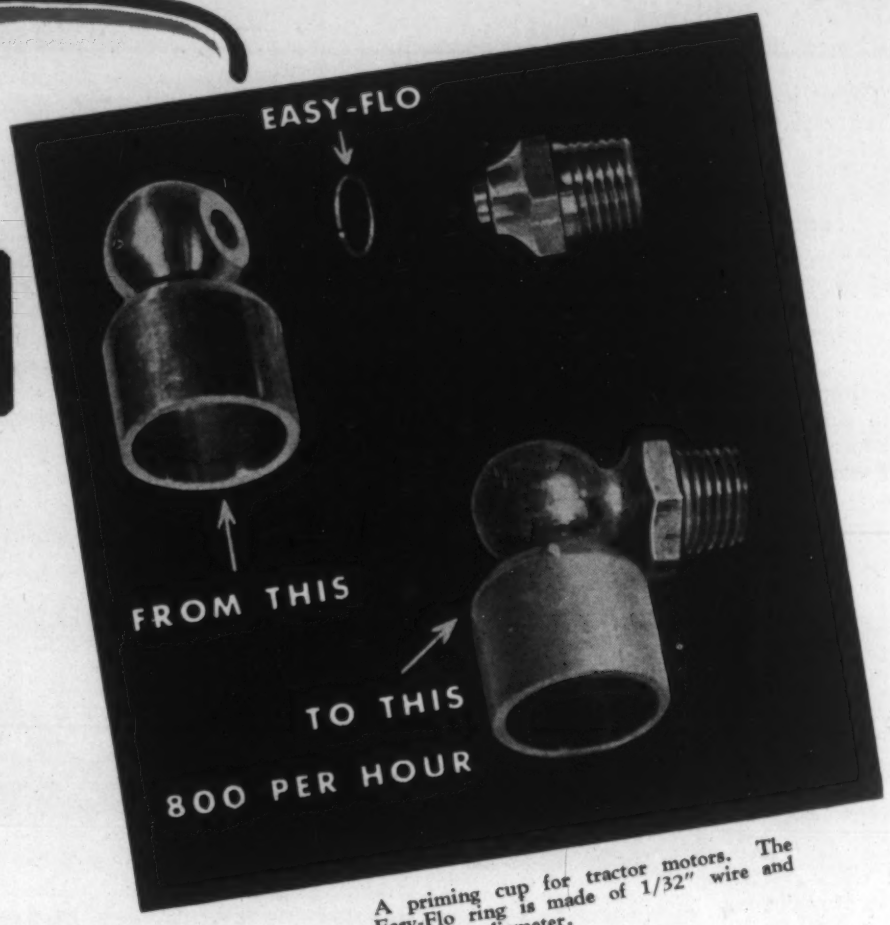
The following steels were used: (1) 0.44% C, 0.24 Si, 0.73 Mn; (2) 0.39% C, 0.26 Si, 0.65 Mn, 0.68 Cr, 1.58 Ni, 0.16 Mo; (3) 0.38% C, 0.28 Si, 0.99 Mn, 1.33 Cr, 0.36 Mo; and (4) 0.13% C, 0.20 Si, 0.45 Mn, 1.3 Cr, 4.45 Ni, 0.85 W. The specimens were hardened with a current of 2000 cycles/sec. and then tested for hardness, microstructure and magnitude and distribution of inner strains.

The size of inner strains on the surface was found to increase with increasing depth of hardening. It reached a maximum for a layer depth of 3-5 mm. (0.12-0.20 in.) depending on the type of steel, and it then decreased with further increase in depth of hardened layer. The depth of the layer at which the maximum strains will occur may be computed from the equation $x = \frac{1}{2}\,[2R - \sqrt{4R^2 - 2(R^2 - r^2)}]$ where x is the depth, R is the outside diam. and r is the inner diam. The strains were found to decrease uniformly from the hardened layer to the unhardened.

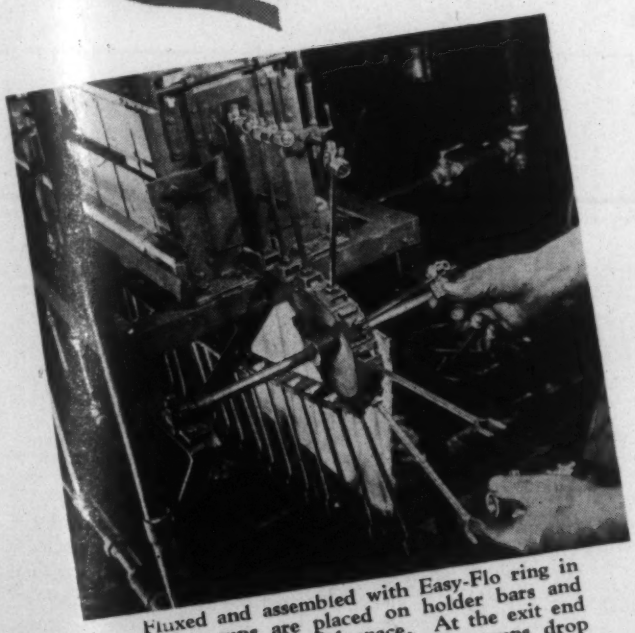
Air cooling and the use of quenching fluids less energetic than water result in a lower hardness. The use of emulsions instead of water is not preferred, either. Inner strains may be reduced by tempering

EASY-FLO

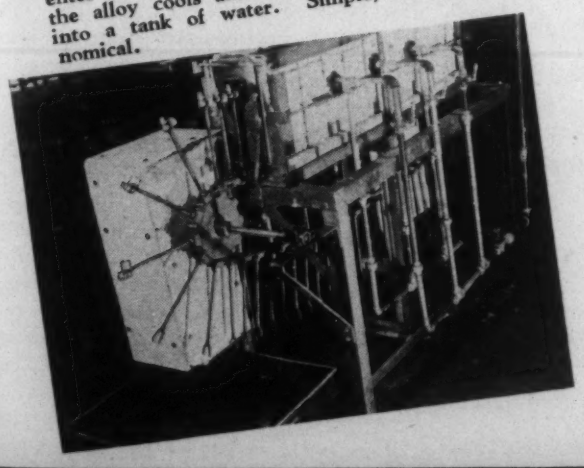
—helps make a big production increase!



A priming cup for tractor motors. The Easy-Flo ring is made of 1/32" wire and is 3/8" in diameter.



Fluxed and assembled with Easy-Flo ring in place, cups are placed on holder bars and enter torch-heated furnace. At the exit end the alloy cools and sets before cups drop into a tank of water. Simple, fast, economical.



FROM 60 per hour to 800 per hour—that's the increase obtained by brazing the brass priming cups illustrated with Easy-Flo.

This increase in production is exceptional but the most important point about it is that it shows what can be done with Easy-Flo and a mass production set-up made to use fully all the advantages Easy-Flo offers.

Easy-Flo is becoming a center around which more and more production jobs revolve because it is the *fastest acting* of all brazing alloys and because it has the *lowest working temperature* of any alloy capable of making high strength joints. Furthermore, Easy-Flo is available in sheet, strip and wire which are readily converted into rings, washers and other forms for *preplacement* which is often the key to economy on large quantity work.

GET ALL THE FACTS

Try this efficient alloy in your plant. You can use it on ferrous, non-ferrous or dissimilar metals. We'll be glad to cooperate. Write for Bulletin MA-10. Let us know if you want a field engineer to call.

HANDY & HARMAN 82 FULTON ST., NEW YORK

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at 300°-400° F. for 2-3 hrs. In the case of steel (4) it was possible to remove 25% of the inner strains by tempering at 400° F. and for steel (1) over 50%. Tempering for longer than 2-3 hrs. does not result in further elimination of inner strains. BZK (2a)

Tool Steels and Their Treatment

"Developments in Tool Steels." J. P. Gill (Vanadium-Alloy Steel Co.) *Can. Metals & Met. Inds.*, Vol. 3, Nov. 1940, pp. 252-256; Dec. 1940, pp. 285-286, 288-289. Review.

Improvements during the past twenty years in production, composition, heat treatment and application of tool steels are reviewed. From the production standpoint, methods have been sought to prevent the central shrinkage cavity (pipe) from extending through the longitudinal axis of the ingot. Big-end-up ingots are now used; standard practice in some mills combines the use of a copper stool, to rapidly conduct the heat away from the lower portion of the ingot, with the use of a solid open-end mold of cast iron with a comparatively heavy taper and thick walls at the bottom. Hammering and rolling have changed little in recent years but heating practice and furnaces for heat treatment have been greatly improved, insuring greater uniformity, better grain structures, and improved surfaces.

Three physical characteristics that may differ greatly in carbon tool steels are: (1) a tendency to grain growth on heating to temperatures of 1450° to 1650° F., (2) a tendency to harden to varying depths, and (3) a tendency to develop soft spots on hardening. Hardenability depends on the quenching temperature and cooling rate, the structure prior to heating, the influence of the grain size developed on heating, and the susceptibility of the steel to grain growth.

The compositions of alloy tool steels for dies for specific uses have been changed materially during the past 20 yrs., many now containing molybdenum. The improvement in air- and oil-hardening characteristics afforded by the use of molybdenum has resulted in the development of very low alloy die steels that show secondary hardness on tempering at about 1000° F. These steels, incidentally, can be nitrided.

A 1% C, 5 Cr, 1 Mo steel is suitable for making intricate dies, punch plates, fixtures, etc., and although it does not show secondary hardness it does retain a high degree of hardness up to 1000° F. A 0.40% C, 16 W, 3 Mo, 4 Cr, 2 Ni steel, on tempering to 1300° F., has a hardness of 444 Brinell, and can be used longer at the higher temperatures than any other type of steel without loss of hardness. The so-called graphitic steels are also of considerable value.

Heat treating improvements are featured by furnace atmosphere control. The most recent development, for the treatment of tool steel that can be hardened from a temperature of less than 2000° F., is an electric-heated muffle furnace using ammonia gas that has been cracked in a separate retort into nitrogen and hydrogen and then passed into the muffle of the furnace. One end of the muffle is kept cold so that when hardening a die of an air hardening steel it can be withdrawn from the hot part of the furnace into the cold part without ever being exposed to air. The die is then cooled to room temperature with the same gases that protect it while it is being heated. WHB (2a)

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Chromium Plating for Longer Wear

"Chrome Hardening Can Increase the Useful Life of Machine Parts." By "Works Chemist." *Sheet Metal Inds.*, Vol. 14, Dec. 1940, pp. 1295-1298. Practical.

"Hard-chromium" plating is used to prolong the life of many types of machine parts and tools, such as plug gages, cutting tools, press tools, some punches, rolls for giving mirror finish surfaces, die casting molds, plastic molds, Lehr rolls, calendering rolls, as well as cylinders, valves, etc. The hard coatings are generally 0.003-0.005 in. thick. Wear is low because of the high hardness (600-900 Brinell) and the low "coefficient of friction" (that of chromium is about 30% lower than that of any other metal).

A satisfactory plating bath contains 25-35% chromic oxide, with the CrO_3/H_2SO_4 ratio about 100 to 1; insoluble anodes (*e.g.* lead) are used, with a temperature of 80°-120° F. Current efficiency is low (only 12-15%) because of hydrogen evolution. Also, a characteristically low throwing power may cause difficulty when complicated shapes are being plated.

The parts must be carefully cleaned before they are placed in the bath. Sometimes it is necessary to provide for mechanical keying or etching of the surface to promote adhesion of the chromium plate. Careful control is necessary at all stages to give precise and reproducible work. Por-

tions of the work on which chromium plating is not required can be painted with a mixture of gilsonite (asphaltum) in xylol. After the plating is completed, the work must be well washed in water, then rinsed in a mild alkali bath to prevent corrosion. If brittleness is to be avoided, the article should be held at 575°-750° F. for about 1-2 hrs.

Although hard chromium plating is expensive (more so than any other plating except precious metals, due to low efficiency and high power consumption), it has many fields of application, since its cost compares favorably with the expense of replacement and the use of special steels, to say nothing of the saving of time in many cases. JZB (2a)

Welding Electrode Coatings

"Iron Oxide as an Ingredient in Welding Electrode Coatings." J. C. Joublanc. *Foote-Prints*, Vol. 13, Dec. 1940, pp. 24-31. Practical review.

Early coating formulas contained fairly large quantities of iron oxide which produced such fluid slags that difficulty was encountered in welding in vertical, overhead, or down-hand positions. For these reasons the use of iron oxide in substantial quantities was abandoned. The increased use of jigs and positioning equipment increased the number of welding operations in flat position so that an efficient down hand electrode was demanded. A number of coated electrodes were developed to meet this requirement, most of which contained large quantities of iron oxide with silica flour or natural aluminum or magnesium silicates.

The iron oxide/silica ratio has a decided effect on the surface tension of the slag. Slags high in iron oxide have a high surface tension and tend to "iron out," which in turn effects the flatness and appearance of the weld.

While magnetite ($FeO.Fe_2O_3$) is most widely used, hematite, siderite and even mill scale are used to some extent. Although iron oxide is soluble in molten slags in appreciable amounts, magnetite is not soluble as such and is altered at the slag-metal interface by reacting with iron.

$$FeO.Fe_2O_3 + Fe \rightarrow 4FeO$$

The oxide thus dissolved is capable of reacting with carbon in the molten metal.

$$FeO + Fe_3C \rightarrow 4Fe + CO$$

Solidification takes place rapidly, making it impossible to expel all the carbon monoxide, which causes porosity in the solidified metal. Diffusion of iron oxide into the metal must therefore be reduced to a minimum.

One of the methods of accomplishing this is by controlling the particle size of the ingredients to permit their proper distribution and at the same time prevent excessive diffusion into the molten metal. Control of particle size also has a definite effect on the viscosity of the slag, unless the rate of work is slowed down to completely melt the slag irrespective of the degree of subdivision. Of even greater importance is the effect of particle size control of the ingredients on reaction with each other in the molten state.

Ferro-manganese is used as a deoxidizing constituent and a substantial amount must diffuse into the weld metal to effect suitable deoxidation. This interferes with the reaction between carbon already present in the core wire and iron oxide introduced during welding. The chemical affinity between oxygen (in FeO) and manganese being greater than it is between oxygen and carbon (in Fe_3C), a solid inclusion will be formed instead of the gaseous carbon monoxide.

$$FeO + Fe_3C + Mn \rightarrow Fe + Fe_3C + MnO$$

If, however, the manganese is in intimate contact with finely divided iron oxide, the reaction

$$FeO.Fe_2O_3 + 4Mn \rightarrow 3Fe + 4MnO$$

will occur in the molten slag, thereby decreasing the amount of manganese available for weld metal deoxidation. This effect of particle size on availability of manganese from the ferro manganese was demonstrated experimentally.

The effectiveness of ferro-manganese as a deoxidizer is decreased in proportion to the reduction in particle size of the iron oxide with which it is mixed in the coating. The rapidity with which slag viscosity is lowered is not a desirable feature since slags that are too fluid are usually responsible for "under-cutting" along the edge of welds. If a coating is composed of ingredients which, themselves, possess high melting points but form low-melting eutectics under the arc, it is best to prevent complete homogeneity by using as large a particle as is practicable, or to include some other ingredient in the coating which will tend to "stiffen" the slag. RAW (2a)

What Gas for Flame Hardening?

"Flame Hardening of Gears." C. B. Hammers (Southern Calif. Gas Co.) *Western Machinery & Steel World*, Vol. 31, Dec. 1940, pp. 458-460. Practical.

Steels of the S.A.E. 1045 and 4650 types can be flame-hardened to 57-60

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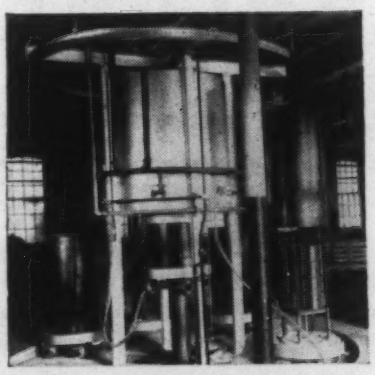

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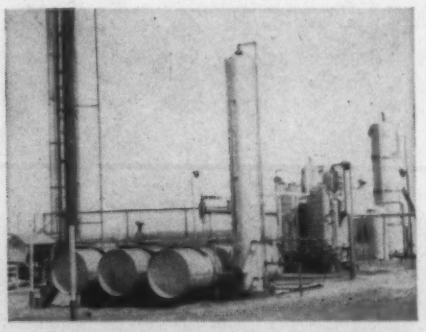

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Rockwell C (water quench is used for S.A.E. 1045 gears; oil for S.A.E. 4650 pinions). Both types are usually tempered at 600° F. to relieve stresses, and the final hardness is about 47 Rockwell C.

A number of tests were made to determine the comparative value of natural gas and of acetylene in flame hardening S.A.E. 1045 gears. No difference was noticed as far as the effect on the structure or properties of steel was concerned, but 1.2-1.5 times as much heat was required for the natural gas as for the acetylene, because of the lower flame temperature of the natural gas. Oxygen consumption was 1.87-2.81 times greater with natural gas than with acetylene.

However, an overall saving of 20-40% resulted using natural gas, owing to the time saved (no tanks to change) and to the low cost of natural gas (in California). [*German experience with city gas in comparison with acetylene for flame hardening was described in our February 1940 issue, p. MA 85.*—Editors.] JZB (2a)

2b. Non-Ferrous

Resistance Welding Aluminum Alloys

A Composite

The extraordinary circumstances that have focussed industrial attention on rapid methods of fabricating the light metals, have, therefore, brought resistance welding —spot, seam, projection and butt—into new prominence. In recent issues we have presented digests on "Spot Welding" (June 1940, p. MA 323), "Spot Welding Aluminum Alloys" (Oct. 1940, p. 556), "Stored Energy Spot Welding" (Nov. 1940, p. 673), and "Spot Welding Aluminum Alloys" again (Jan. 1941, p. 87). A very good review of the whole field of resistance welding of aluminum alloys is found in the 2 articles abstracted herewith.

Spot Welding

The British Institute of Welding has been running tests of spot welds made on 17ST, alclad and an aluminum-magnesium alloy (M.G. 7) to determine weld properties, study the effect of various special treatments, and incidentally compare the welded joints with riveted. GORDON H. FIELD & H. SUTTON ("Investigation on the Spot Welding of Light Alloys," *Trans. Inst. Welding;* Vol. 3, July 1940, pp. 157-174) report the results, based on the practical experience of 3 commercial welderies and considerable fatigue, static shear, X-ray and micrographic data.

As-welded shear and fatigue tests and tests after heat treatment and aging indicated that static shear properties have a divergence from maximum and minimum values of from 4 to —5% to 29 to —12%. The variation bears no relation to size or the average strength of the welds. The strength of the spot welds is closely related to the strength of rivets of similar size. Heat treatment increased the static shear strength 17 to 57%. When welded with a "program control" machine, the heat treatment resulting from this process increased static shear strength 16-23% with no appreciable difference in maximum and minimum values.

In some of the welds, streaks of a pink constituent (unetched) were found along the interfacial plane of the weld, and this is considered to be a complex eutectic of an Al-$CuAl_2$ type. The hardness invariably drops in the fused zone from 110 in the sheet to 80 or 70 in the weld.

Comparisons of the spot welds made by the 3 companies indicated that the smallest welds were the soundest and showed the highest shear strength. In the larger welds the unsoundness takes the form of fissuring by hot cracking of the central part of the weld during cooling. This was shown in X-ray and micrographic examination although no external evidence of unsoundness was seen for any of the welds.

Welds in thinner gage material have greater soundness. Fatigue cracks usually go through the sheet at the edge of the weld, and therefore the properties here are of greater importance for endurance than the weld itself.

Seam, Projection and Butt Welding

Although spot welding is most widely used for aluminum, other methods of resistance welding can be employed, and "AGRICOLA" ("Seam, Projection and Butt Welding," *Sheet Metal Inds.*, Vol. 14, Nov. 1940, pp. 1215-1217) discusses them. Seam welding consists of making a row of overlapping spot welds giving a continuous liquid-tight joint. The "shunt effect" or loss of power by short circuiting is considerably greater than in spot welding, with a resultant greater general heating of the sheets, more warpage, more pronounced softening, and more severe electrode service.

In seam welding, the cooling of the electrodes must be particularly efficient to prevent sticking, contamination, and mushrooming; cold worked, lightly-alloyed copper is successfully used for electrodes, but some of the heat-treated copper alloys

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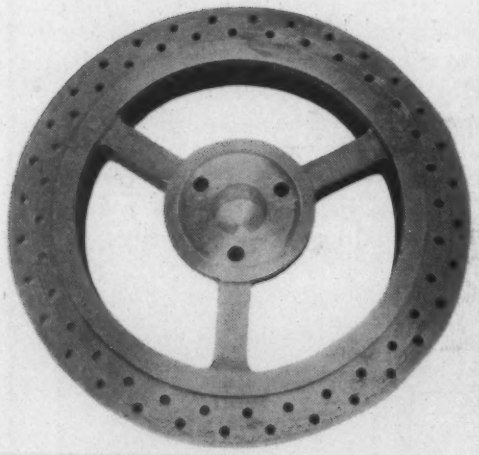

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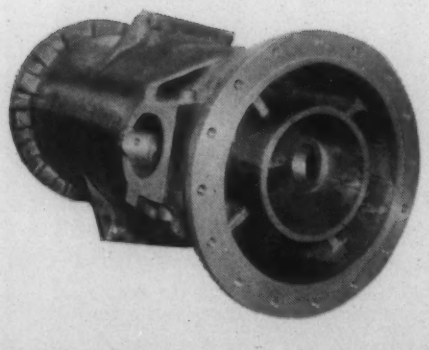

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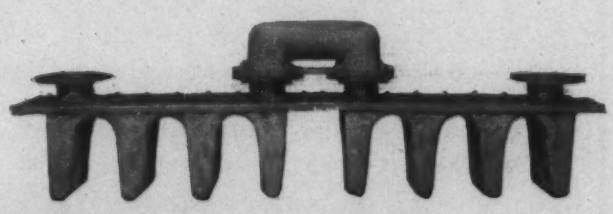

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are recommended for seam-welding rollers. Heavy rollers, 4-6 in. in diam., assist liquid-cooling in keeping down the temperature of the electrodes.

There are 2 types of machines: a.c. with transformer and controllers, and "stored energy" equipment giving a uni-directional current impulse. High precision controllers must be used; the "on" period is usually 50-80% shorter than the "off" period with the total welding cycle 0.1-0.3 sec. Current must be 30-50% higher than in spot welding to offset the shunt effect.

Any of the usual aluminum alloys can be welded up to about 0.1 in. thick. Seam welding is economical only for standard shapes and joints, *i.e.* aircraft oil tanks, refrigerators, etc., where the saving resulting from higher speed of operation is justified. The butt seam method has not been used for aluminum.

Projection welding would be expected to have 2 main advantages over spot welding: A number of spots are made simultaneously, and the size of the weld is not dependent on the size of the electrode at the moment of welding. These would mean higher production figures at reduced cost, but the method has not been too successful yet for aluminum, as the projections collapse suddenly leading to spattering and sticking rather than welding. Future developments in this field are to be expected.

Butt welding, either flash or simple fusion, gives good welds but has not been widely used. The refractory oxide film and the high conductivity of aluminum are the main difficulties. Flash welding cannot be used for thinner gages or for highly stressed components due to entrapped oxide and the presence of pores. It is used for wheel rims, etc., and is recommended for joining aluminum to other metals. Simple resistance butt welding has been used for about 40 yrs. X (2b)

Anodizing Aluminum Alloy Welds

ANODIC OXIDE LAYERS ON ALUMINUM, PARTICULARLY ON WELDED JOINTS ("Ueber elektrolytisch erzeugte Oxydschichten auf Aluminium, insbesondere auf dessen Schweissverbindungen") C. AUCHTER. *Aluminium*, Vol. 22, Nov. 1940, pp. 569-575. Practical.

Oxide layers produced anodically (in sulphuric or oxalic acid) on aluminum and aluminum alloys increase resistance to atmospheric influences, improve appearance and physical properties, and give better electrical insulation and reflectivity.

While the thickness of the oxide film produced in air at room temperature is of the order of 4×10^{-6} cm., and that at melting temperature is $2—4\times10^{-5}$ cm., anodic oxide may be as thick as $2—30\times10^{-4}$ cm. As the films on pure aluminum are transparent, the light rays pass through them and are reflected on the metal so that the crystal faces appear dark or light, and changes in the structure, *e.g.* due to welding, become visible.

If, therefore, a piece is to be welded that later is to be anodically oxidized, the welding rod used should be carefully selected, and special care exercised that no additional alloying element is introduced *via* the weld. The thickness of the oxide film over the weld is practically the same as over the base metal, the difference being only ±0.001 mm. It makes no difference whether the films are produced with alternating or direct current.

If (especially for decorative applications) the welded joint must not be visible, such aluminum alloys are used that are homogeneous and not subject to segregation under the influence of heat; therefore, in

SALTS for BLACKENING STEEL

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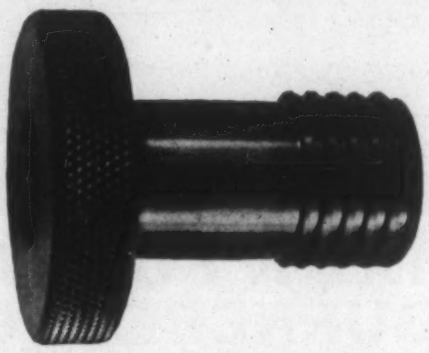

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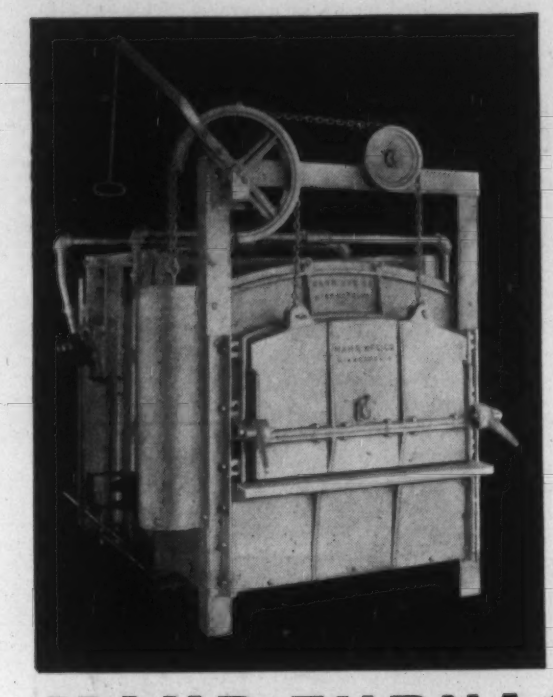

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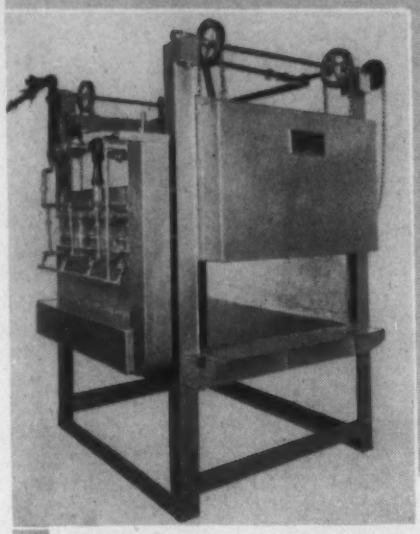

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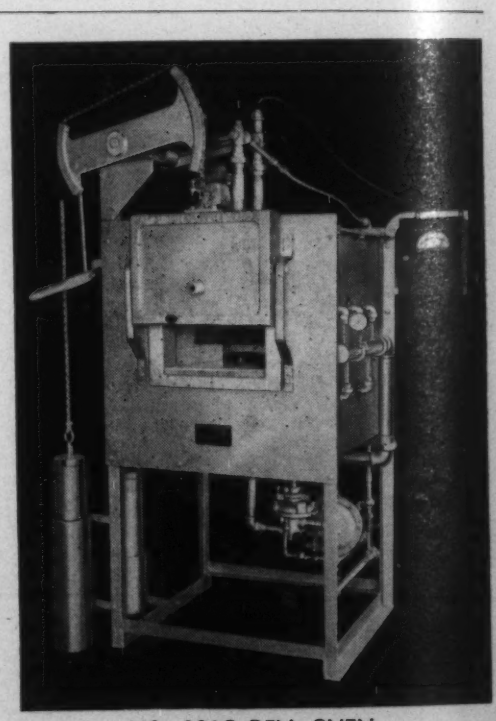

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addition to pure aluminum, alloys with about 3% Mg are preferably used for this type of work. Before oxidizing, the weld should be rapidly cleaned and degreased in sodium hydroxide and then nitric acid; for polished surfaces benzene or similar solvents may be used. Ha (2b)

Aging Copper-Silver Alloys

"Precipitation in the Alloys of Copper and Silver During Age-hardening." W. F. Cox & C. Sykes. *J. Inst. Metals*, Adv. Copy No. 885, 1940. Research.

A silver-rich and a copper-rich alloy were quenched from 1435° F. The former was aged at 465° F. and the latter at 715° F. Hardness measurements and X-ray diffraction patterns were made after different aging times.

The results proved that before maximum hardness had been reached particles of the precipitate were present to the extent that they could be detected in the diffraction patterns. It was estimated that the minimum size of the precipitated particles at maximum hardness was of the order of 100 A. U.

Upon age hardening of the silver-rich alloy considerable broadening of the lines of the parent metal took place and this was accompanied by grain refinement. Both these effects are associated with a highly strained lattice. In the copper-rich alloy, where relative hardening is small, very little lattice distortion or grain refinement was observed, suggesting that the residual strain remaining in the hardened lattice is not high. JLG (2b)

Salt Bath Practice for Aluminum Alloy Parts

"Nitrate Salt Bath." A. C. Finch. *Sheet Metal Inds.*, Vol. 14, Dec. 1940, pp. 1286-1290. Practical.

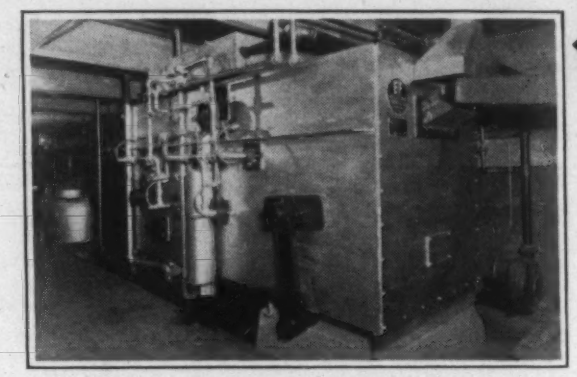
Nitrate baths are widely used for the solution heat treatment of aluminum alloys. The advantages of such practice are the rapid, uniform heating, and the minimum surface oxidation obtained; the chief disadvantage is the possibility that salt adhering to the surface may be driven into the metal on subsequent forging, although this can be prevented by a quick dip in boiling water before forging is started.

Normal bath temperature is 900°-1000° F., so either sodium nitrate (m. pt. 590° F.) or a eutectic mixture of sodium and potassium nitrates (about 45.2% of the sodium salt, although 50% is usually used; m. pt. 425° F.) can be used. Since nitrates are powerful oxidizing agents, suitable precautions must be taken in storing salts. In starting up the bath, only perfectly dry salt should be used, and melting should be done very slowly (about 2 days for a 10-ton bath) to prevent overheating. Additional salt should be added only when the melt is solid.

Temperature should be perfectly controlled, preferably with 2 pyrometers: one permanently installed, while the other is used to detect hot spots. Nitrite content should be determined once a month. The presence of nitrite is not in itself very harmful, but its rate of formation is significant as a too-rapid rate will indicate too much organic matter entering the unit or a hot spot due to faulty furnace design or accumulation of sludge. On shutting down, sludge should be removed from the bath and, if possible, the salt should be removed and the container carefully examined for corrosion.

Container failures can be caused by local overheating or by a sort of thermit reaction that may take place if light alloy parts are allowed to remain at the bottom of the bath in contact wih scale and hot nitrate. Ingot iron with under 0.06% C is preferable to mild steel for containers; 15% Cr steel is resistant to attack but may become embrittled in service. High chromium-nickel and aluminum-chromium-silicon steels (analysis not given) are particularly free from scaling. Calorized and nickel-lined containers have also given good service. The presence of sodium chloride in the bath seems to increase the nitrate attack, but the author feels that the effects of overheating override the chloride effect in every case. [*These statements should be compared with the conclusions of Lloyd & Chamberlain—reported in our January 1941 issue, p. 82—who, like Finch, noted that chlorides stimulated corrosion and that ingot iron resisted corrosion better than mild steel, but who minimized the importance of local overheating as an essential cause of corrosion at the overheated spots.*—F.P.P.]

Alloys with high magnesium content should never be heat treated in nitrate baths as a violent reaction occurs. Some effects attributed to nitrate baths are really due to improper procedure. "Nitrate corrosion," found especially on Alclad sheets, is caused by improper washing after quenching and to condensation of moisture on sheets during storage after treatment. Blistering is generally the result of overheating. If properly used, nitrate baths are efficient and give little trouble in the heat treatment of aluminum alloys. JZB (2b)



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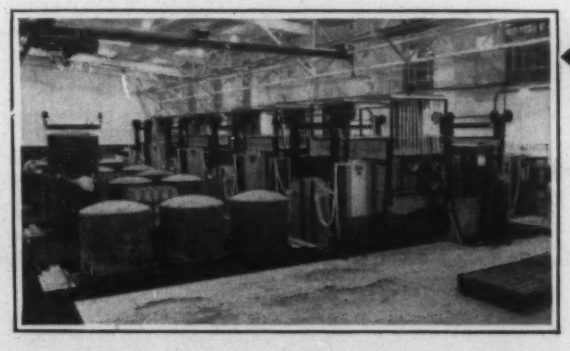
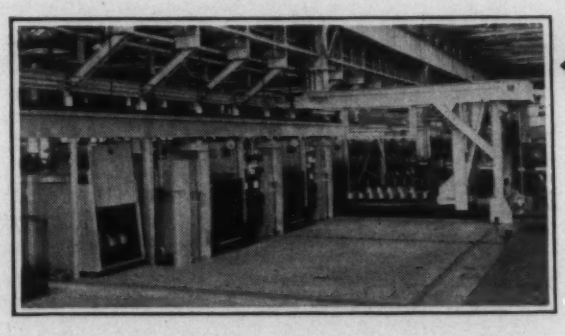


Aircraft Engine Parts

Aircraft engine parts are nitrided in this battery of double-ended reciprocating type furnaces — part of the world's largest nitriding furnace installation. These furnaces were designed and built by E.F. engineers and installed in a prominent aircraft engine plant.

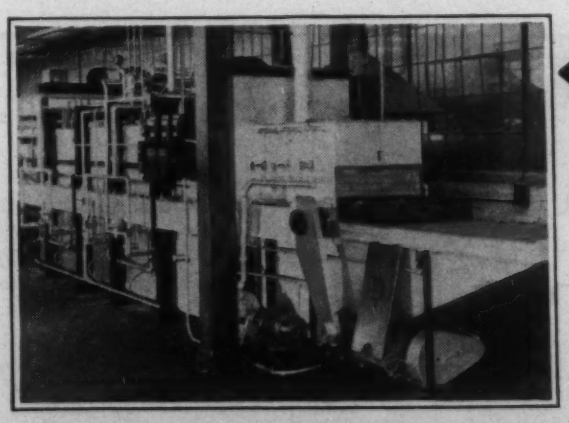
EF



Brass for Cartridges

Brass for cartridges and other products are uniformly treated in various types of E.F. furnaces. This installation shows 3 gas-fired, hearth type forced circulation furnaces with quench, cooling chamber and handling crane—one of several similar installations we made in prominent non-ferrous plants.

EF



Annealing Shells

Designed for annealing brass shells, this E.F. gas-fired continuous roller hearth furnace is also adapted to treating steel shells. Large shells are carried direct on rollers—smaller shells are loaded into pans or trays. Built in various sizes.

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3 Properties and Applications

METALS, ALLOYS, METAL FORMS ENGINEERING DESIGN, METAL SELECTION

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

Application of Extruded Parts

A Composite

Non-ferrous alloy extruded parts have become increasingly familiar in the last few decades. With the current expansion in the aircraft industry, the growth in the use of extruded aluminum alloy has been particularly noticeable, and magnesium alloy extrusions, too, are broadening their applications. During the last 5 years—as Cudebec points out in his article abstracted below—the production of extruded tubing, shapes and rods of stainless steels, nickel alloys and bearing steel has attained commercial importance and given the metallurgical engineering designer new metal-forms with which to work.

Some of the general advantages of extrusion (and the extruding process) have been cited by Pannell in an *Iron Age* article (of which a digest appears in Digest section 1b of this issue) on aluminum alloys. Lower manufacturing costs, and a grain structure that is better for some purposes than that obtained by rolling and drawing, seem to be important advantages of the extruding process.

A special advantage of the process cited by A. B. CUDEBEC ("Recent Developments in Metal Extrusion," *Mech. Engineering*, Vol. 63, Jan. 1941, pp. 16-18) is that it provides an economical means of fabricating certain materials that are ordinarily difficult to process by rolling, welding or piercing—such as the stainless steels—and of producing components in certain alloys that cannot be successfully rolled at all without developing serious faults. An additional advantage is that extruded tubing can be drawn to smaller sizes at a lower cost than tubes produced by piercing or other processes.

About 50% of the products extruded from light metals are finished profiles that only require straightening and in some cases heat treatment before being completed. The remaining 50% is extruded into round bars, strips and other semi-finished products, which are subsequently formed into thin strips and other articles by cold rolling. The preliminary extrusion in this latter case confers malleability without sacrifice of tensile strength and uniform grain structure in the finished state.

Tubing can be commercially extruded in sizes from 1¼ in. to 4 or 5 in. o.d. However, 75% of the commercial demand for alloy tubing is for sizes below 3 in. There is no practical upper limit to the wall thickness that can be economically extruded, but the minimum wall that can be extruded for most alloys is about 0.16 in.

Additional data of value to engineers interested in extruded parts are given by W. RÖLLINGER ("Die Anwendung des Kaltspritzverfahrens," *Aluminium*, Vol. 22, Oct. 1940, pp. 511-518). He gives the maximum diameter of round extrusions as 4 in.; for rectangular parts the maximum section is about 12.2 in.², with the largest ratio of sides 1:5. Lengths greater than 10 in. are not produced, as the dies collapse; a good rule of thumb is length = 5–10 x diameter or length of smallest side.

Clad materials are now being extruded. Tin-plated tubes have thus been made in which the tin layer was only 2.5% of the tube wall thickness—or about 0.002 in. tin.

Extrusion of tubes has been standardized in Germany. In competition with the deep-drawing process, extruding permits finishing in one operation and the use of a cheaper starting material, since the latter may be thicker for extruding than for deep-drawing. X (3)

Bearing Lubrication

"THE FRICTION OF LUBRICATED METALS." E. P. BOWDEN & L. LEBEN. *Phil. Trans. Roy. Soc.* [*A*], Vol. 239, June 1940, pp. 1-27. Original research.

The forces required to drag a slider over a lubricated surface were recorded continuously and with great accuracy. Two methods were employed for applying the lubricant.

In the first, the surface was covered with the lubricant and the excess wiped off, leaving a film several thousands of molecules thick. When alcohols, saturated hydrocarbons, or lower fatty acids were used, sliding occurred in a series of jerks, the metals alternately seizing and breaking away from each other. Only when the higher fatty acids were used was sliding continuous; and with these the coefficient of friction fell as the molecular weight of the lubricant was raised, until with caprionic acid (mol. wt. = 150) the coefficient was found to be 0.1.

In a second series of experiments, unimolecular films of the lubricants were formed on a water surface and transferred to the steel. By repeated applications, files of any required thickness were produced. Layers of stearic acid and cholesterol were found to cause a large reduction in friction but they wore and broke down rapidly.

It is concluded that the frictional behavior of boundary-lubricated surfaces is largely governed by the extent to which the film breaks down during sliding.

JCC (3)

3a. Ferrous

Fatigue Properties of Low-Alloy Steels for Aircraft

ALTERNATING BENDING TESTS AND METALLOGRAPHIC INVESTIGATIONS OF WELDED THIN SHEETS OF HIGH STRENGTH STEELS ("Biegewechselversuche und metallographische Untersuchungen an geschweissten Dünnblechen aus Stählen hoherer Festigkeit") R. MAILÄNDER, W. SZUBINSKI & H.-J. WIESTER. *Tech. Mitt. Krupp, Forsch. Ber.*, Vol. 3, Nov. 1940, pp. 199-221. Investigation.

High strength-weight ratio and good weldability are the most important requirements for structural components of modern aircraft. Seven carbon, chromium-molybdenum and manganese alloy steels with tensile strengths of 75,000-110,000 lbs./in.² as used in airplane design were investigated in the form of 0.05 and 0.10 in. sheets in the (a) unwelded, (b) gas-welded, and (c) atomic-hydrogen-welded conditions; welds were not subsequently heat treated. Hardness, metallographic structures and bending fatigue strength were investigated.

The steels were:

A—normalized plain carbon steel with 0.30% C and 0.56 Mn
B—normalized plain carbon steel with 0.56% C and 0.63 Mn
C—heat-treated chromium-molybdenum steel with 0.24% C, 0.48 Mn, 1.06 Cr and 0.21 Mo
D—heat-treated chromium-molybdenum steel with 0.24% C, 0.64 Mn, 1.01 Cr and 0.19 Mo
E—heat-treated manganese steel with 0.38% C and 1.20 Mn
F—normalized "Izett 50" steel with 0.12% C and 1.53 Mn
G—normalized "Izett 70" steel with 0.21% C and 2.17 Mn

In the unwelded materials the bending fatigue strength increases with increasing tensile strength (although not to the same degree). However, this is not always the case in the welded condition for these steels. A previous observation that bending fatigue strength increases with decreasing thickness of the sheet was confirmed.

The chromium-molybdenum and Izett steels had in the welded state a bending fatigue strength of 31,000-35,500 lbs./in.² for an average sheet thickness of 0.07 in. (somewhat higher for thinner, somewhat lower for thicker, sheets). The low-carbon steels "50" and "70" were equal to chromium-molybdenum steels in the same tensile strength range, and some had a lower weld sensitivity. The welding methods had little effect on bending fatigue strengths. Subsequent grinding of the welded seams improved the fatigue strength.

With regard to the structures developed in the heat-affected zones, all these steels in the thicknesses studied behave "critically" when cooled—comparatively small variations in the cooling velocity give quite different structures and hardnesses. Every effort should therefore be made to reduce the cooling velocity as much as possible (by preheating the welded area, by cover-

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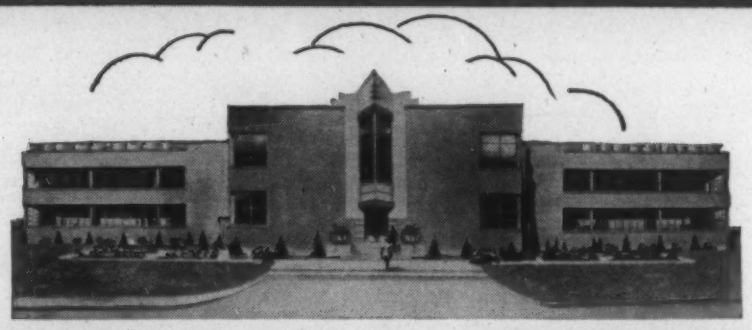

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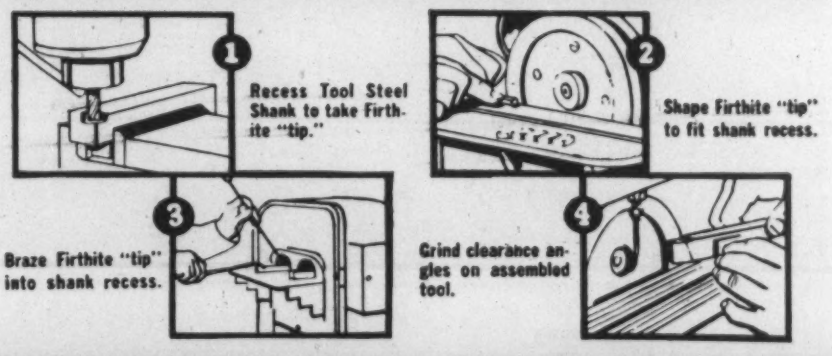

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Eclipse Counterbore Co. 7410 St. Aubin Ave.....TR inity-2-4581
Falcon Tool Co. 12502 Greiner Ave.....PI ngre-4800
The Gairing Tool Co.1629 W. Lafayette St.....RA ndlph-7927
Genessee Tool Co. 6432 Cass Fenton.....MAdisn-6300
Goddard & Goddard 12280 Burt Rd.....RE dfrd-3000
Gorham Tool Co. 14400 Woodrow Wilson Ave.....TO wnsnd-8-0020
Midwest Tool & Mfg. Co. 2360 W. Jeff.....LA fayet-0055
Morse Tool Co.116 E. Goldengate Ave.....TO wnsnd-8-2090
Motor Tool Mfg. Co. 12281 Turner St.....HO grth-5300
Production Tool Co. of America 6474 Le Grand Ave.....PL aza-6717
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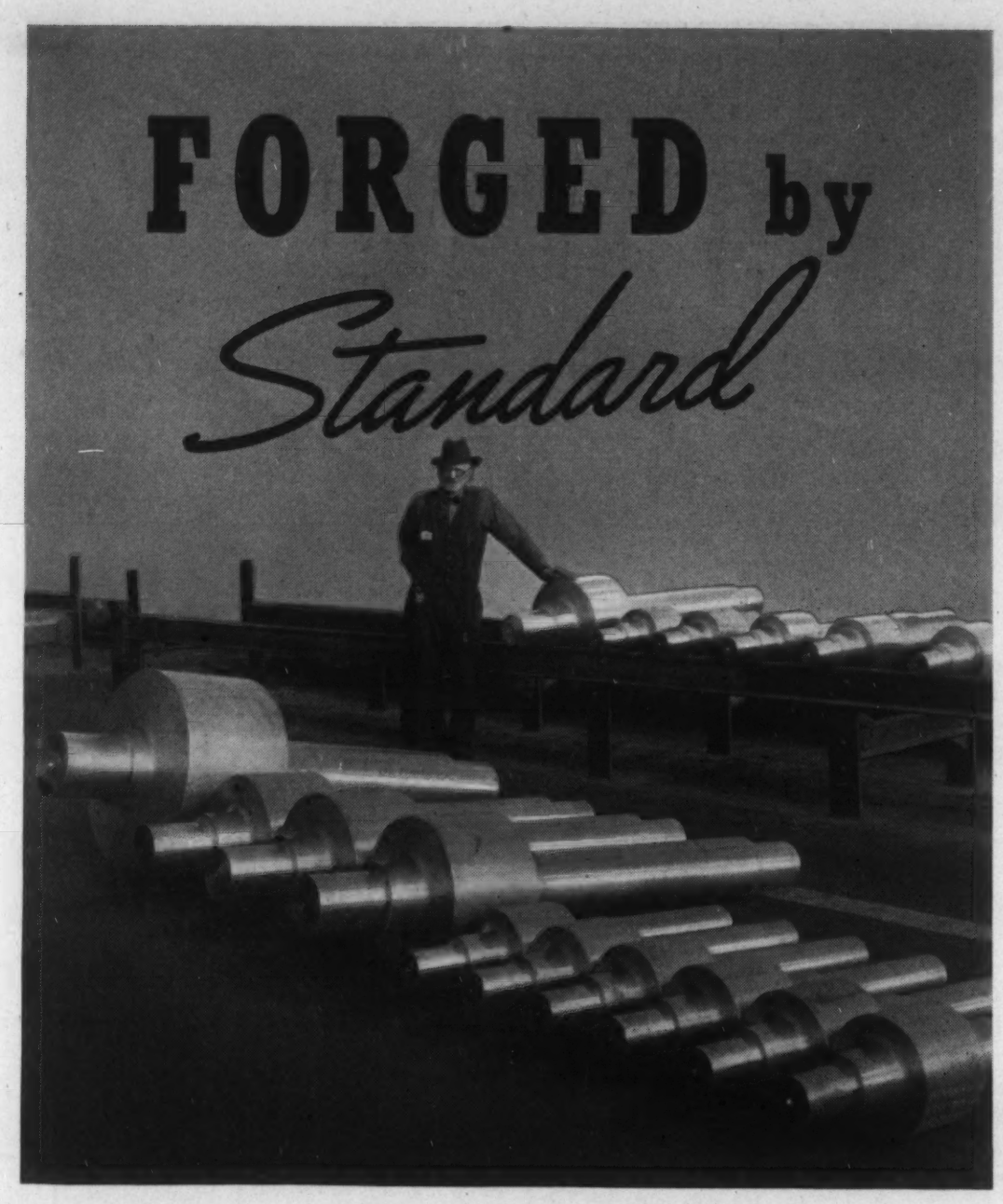

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ing, etc.). A low-carbon content of the alloy guarantees comparatively low hardness even if full hardness is obtained so that a certain toughness remains.

The ratios of bending fatigue strength to tensile strength were found to be as follows:

Type of samples	0.05-in. Sheet	0.10-in. Sheet
Not welded	0.45	0.38
Gas welded	0.39	0.32
Gas welded, beads ground off	0.62	0.43
Atomic hydrogen welded	0.36	0.32
Atomic hydrogen welded, beads ground off	0.52	0.38

Ha(3a)

Aircraft Fuselages of Steel Tubing

"Steel Tube Fuselages." J. E. Thompson & T. A. Lowe (Vultee Aircraft, Inc.) *Product Eng.*, Vol. 11, Oct. 1940, pp. 436-442; Nov. 1940, pp. 513-517; Dec. 1940, pp. 549-551; Vol. 12, Jan. 1941, pp. 28-32; Feb. 1941, pp. 63-65. Descriptive.

The welded-steel-tube type of fuselage for the smaller commercial and military aircraft permits fabrication of the fuselage in simple accessible jigs and makes possible the application of the fuselage skin or covering as the last assembly operation.

Two basic forms of tubing-fuselages are employed—an all-steel-tube truss, and a so-called "composite" structure with the forward portion of tubing and the aft section of aluminum alloy semi-monocoque. The form is preferred by some because it employs a single fabrication process throughout and because it permits access to the full length of the fuselage during assembly. The second is liked by others because it provides lighter weight and faster fabrication in plants having sheet-metal forming equipment.

The radial engines currently in favor permit simple engine mount design, basically a steel tube ring connecting to the engine mounting lugs. Junctions of rings and tubes should not be located directly at engine attachment fittings, to permit planar alignment of the fitting faces by local heating after welding. This is especially desirable if a fairly high tolerance (about ± 0.010 in.) can be allowed on this planar alignment.

A generous tolerance will permit final sizing of the fittings prior to final welding. When close tolerances are required, final sizing, facing and reaming of fittings may have to be completed *after* welding. This means that the complete and generally awkward assembly must be handled during these machining operations, with consequent increase in production time.

Steel forgings for engine mount attachment fittings are standard practice. The forging's walls are usually heavier than required for service and much heavier than the walls of the tubes welded to them, and local pre-heating of the fitting may be required. An alternative is to machine the forging down to a smaller wall thickness.

In most planes the wing-to-fuselage attachment involves connection of front and rear wing spars to the fuselage lower longerons, thus requiring 4 attachment points. The desirable practice of making each with a single bolt can be accomplished by welding steel bar bosses to both sides of the longeron for the attachment bolt, with a through gusset providing sufficient weld area for adequate stress transfer.

In a composite type fuselage, attach-

SYMBOLS of DEFENSE

CIRCLE L

PROUD EMBLEMS of the combat Divisions of the Army of the United States. The men who wore them wrote a gallant page in the defense of American democracy along the banks of the Somme, the Marne and the Meuse, in the forest of the Argonne and the hills around Verdun. Today the men of these same divisions from coast to coast stand ready to answer their country's call to defend that democracy against any who dare to endanger it.

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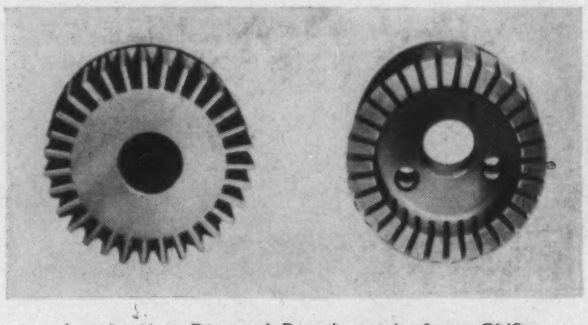
JESSOP CNS

An Outstanding General Purpose High Carbon High Chromium Die Steel



Lamination Die and Punch made from CNS

Jessop CNS is a 1.50% carbon, .75% molybdenum high chromium vanadium die steel possessing good machinability, minimum size change, and toughness with remarkable wear resistance. These balanced properties make CNS an ideal die steel for general purpose work where high wear resistance combined with shock-resistance is desirable. The same hardness is developed by air hardening as by oil hardening.

If you have an application requiring extreme wear resistance, we recommend Jessop 3C oil hardening die steel. If first cost of die is of primary importance, investigate Jessop WINDSOR SPECIAL air hardening die steel. Literature on all three types of Jessop High Carbon-High Chromium die steels will be sent free upon request.

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Chain Belt Company	Milwaukee, Wisconsin
Chicago Railway Equipment Company	Chicago, Ill.
Eastern Malleable Iron Company	Naugatuck, Conn.
Erie Malleable Iron Company	Erie, Pa.
Gunite Foundries Corporation	Rockford, Ill.

Heat treating furnaces for the production of Z-Metal are manufactured under license by Westinghouse Electric & Mfg. Co. and General Electric Company.

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ment of the steel-tube forward section to the aluminum alloy semi-monocoque aft section is by a forged fitting similar to that used for engine-mount attachment. For permanent connection of 2 tubes in any structure, the "welded telescope" type of joint is generally used.

Two simple factors govern the basic design of all detail fittings—welding accessibility and balanced joints. Wall thicknesses and sheet gages of the major fittings are usually large enough to minimize balanced-joint considerations. But most detail fittings are thin sheet metal parts welded to heavy-wall tubing, or *vice versa*, and considerable ingenuity in their design is required, with especial emphasis on having brackets that permit adequate clearances for rapid production with standard welding equipment. (3a)

Vanadium Cast Irons

"Vanadium in Cast Irons." E. Piwowarsky. *Foundry Trade J.*, Vol. 63, Nov. 28, 1940, pp. 345-346; Dec. 5, 1940, pp. 363-364; Dec. 12, 1940, pp. 383-384 (translated from *Giesserei*). Investigation.

The structure of cast iron is sometimes appreciably refined by addition of vanadium, the vanadium-rich carbide tending to the spherical form, unlike lamellar pearlite. In view of the great affinity of vanadium for carbon, free iron carbide occurs only after the larger part of vanadium has been used up in forming V_4C_3. With 2% V, for instance, iron carbide occurs in the structure only above 0.4% C.

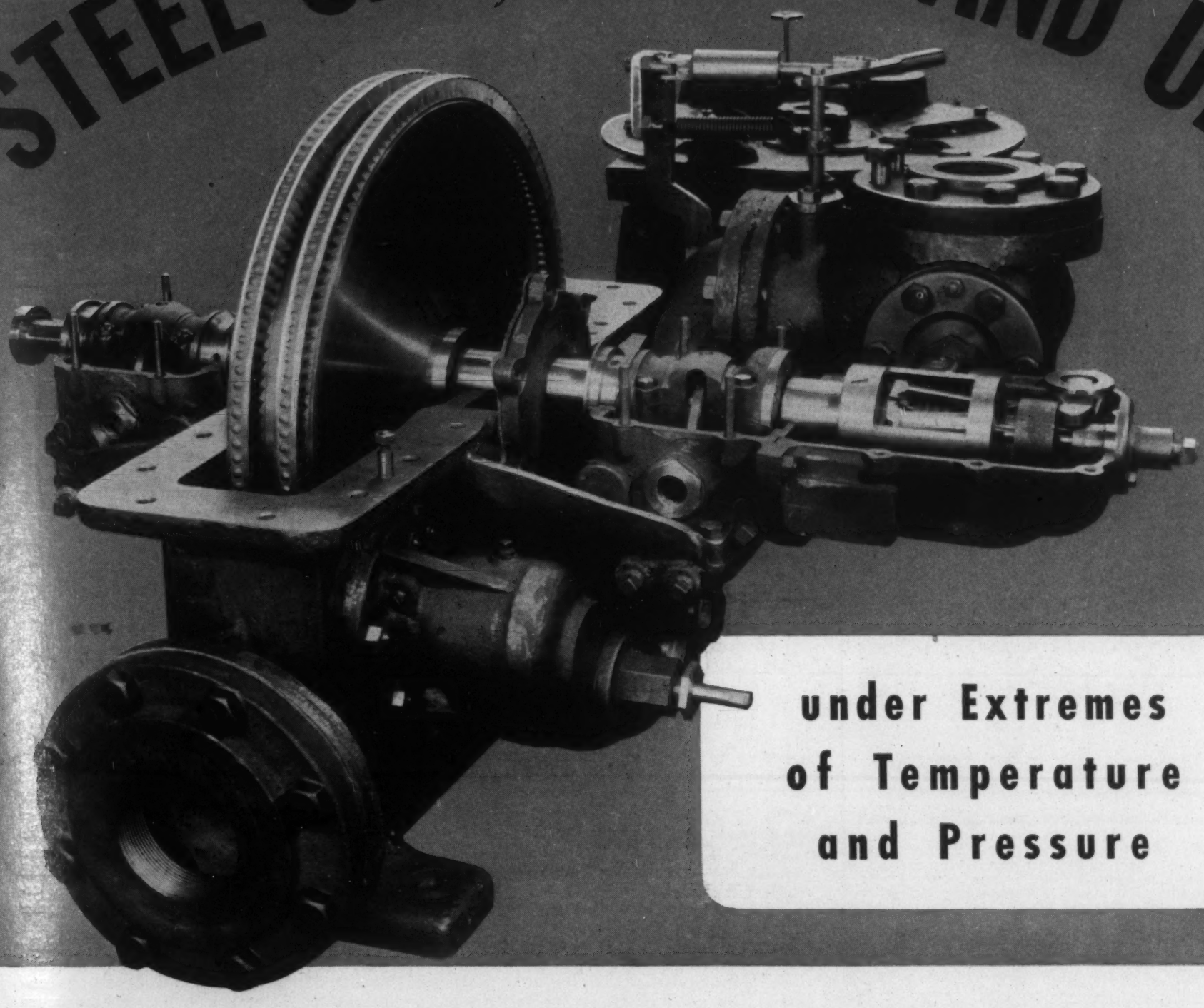
If the addition of vanadium to steel and cast iron produces a marked alteration in the pearlitic structure (tendency to fine sorbite) this may be connected with (1) the deoxidizing effect of vanadium, or with the seeding effect of the numerous finely-divided vanadium carbides, or (2) with the possible existence of a slight mutual solubility of the iron and vanadium carbides.

Since the major portion of the vanadium carbide probably separates out even in the molten mass, this carbide separation should have an appreciable effect on the undercooling of the eutectic. The special value of vanadium as a ladle addition to low-carbon cast iron for preventing graphite formation is thus indicated. [*A composite digest in our June 1940 issue, p. MA 316 cited data by Wisser establishing the lower carbide-forming value of ladle additions of vanadium as compared to cupola additions.*—F.P.P.]

The early observations by the author on the increase in the carbide-promoting influence of vanadium at contents above about 0.5% V agree with more recent results. The effect of vanadium is most pronounced in iron with less than 1.5% Si. Numerous effects of vanadium in cast iron can be explained by the fact that the vanadium carbides, which are negligibly soluble in molten iron, remove carbon from the material.

Up to the present, additions of vanadium have given satisfactory service in the production of cylinder liners, piston rings, high-strength machinery castings, chilled cast-iron rolls, ingot molds, glass molds and possibly also firebars. In conjunction with nickel or molybdenum, vanadium is an important constituent of heat-resistant castings that have an approximately constant hardness and volume up to 1200° F. In general, vanadium appears to be able to replace chromium rather than molybdenum in cast iron. AIK (3a)

STEEL CASTINGS STAND UP...



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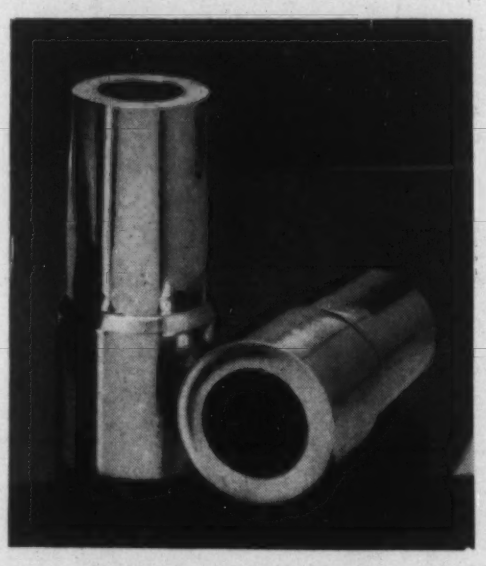
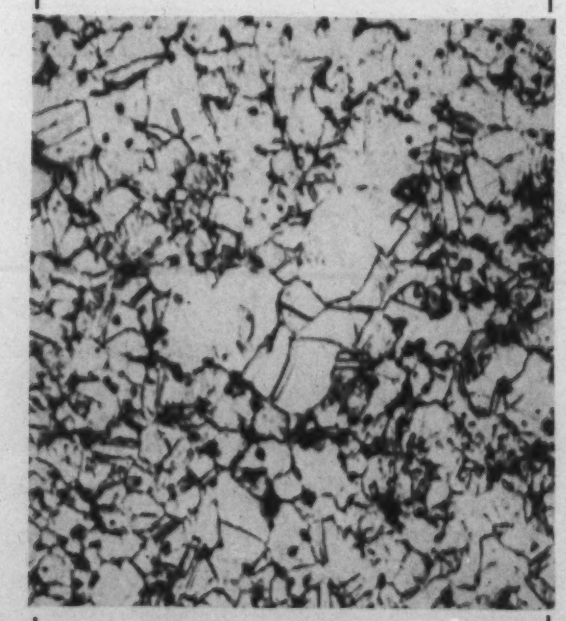


A typical POMET part now being made which incorporates material and shape advantages—length 3½"; max. O.D. 1½"; min. O.D. 1"; wall thickness app. ¼" with uniformly tapered hole.



Photomicrograph of POMET #1127 (Cu Zn Sn Pb Alloy) used in the manufacture of above part (250 diameters).

Submit blueprints and specifications for quotation.

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High-Manganese Carburizing Steels

COMPARISON OF DIFFERENTLY ALLOYED CASE-HARDENING STEELS, WITH PARTICULAR ATTENTION TO THE CHROMIUM-MANGANESE STEELS FREE OF STRATEGIC [NON-GERMAN] ALLOYING ELEMENTS ("Vergleich verschieden legierter Einsatzstähle unter besonderer Berücksichtigung der sparstoffarmen Chrome-Mangan-Stähle") H. SCHRADER & F. BRÜHL. *Tech. Mitt. Krupp., Forsch. Ber.*, Vol. 3, Nov. 1940, pp. 243-253. Investigation.

There has been a decided trend in Germany in recent years to develop and employ steels that are satisfactory for each specific service rather than to improve the quality and mechanical strength of a steel at any price. This tendency has led to the replacement in many cases of high alloy steels by simpler and cheaper materials.

The possibility of replacing the high-alloy chromium-nickel steels and also the chromium-molybdenum steels by low-alloy steels, of the compositions and properties indicated in the Table, was studied.

Designation	"Heat-treated" tensile strength lbs./in.²	Elastic limit, % of tens. st.	Composition				
			C	Si (max.)	Mn	Cr	Mo
EC 30	78-100,000	65	0.10-0.16	0.35	0.4-0.6	0.3-0.5	
EC 60	100-128,000	70	0.12-0.18	0.35	0.4-0.6	0.6-0.9	
EC 80	120-155,000	70	0.14-0.19	0.35	1.1-1.4	0.8-1.1	
EC 100	155-200,000	70	0.18-0.23	0.35	1.2-1.5	1.2-1.5	
ECMo 200*	170-210,000	70	0.17-0.23	0.35	1.3-1.5	1.7-2.0	0.15-0.25

* Can be used only with special permission.

Investigation of the influence of small changes in composition on the properties of the core showed that in the hardened state each of these steels corresponded fully to the demands made on the higher alloy steels of the same strength class. The fracture had a granular appearance in the core zone in both EC 80 and its lower-manganese, molybdenum-bearing counterpart of the same tensile strength. On the other hand, in EC 100 and the low-manganese, chromium-molybdenum German steel of the same strength class the fracture is stringy up to 0.045 in.² section and becomes granular at larger sections.

With regard to core properties, EC 100 and its higher alloy counterpart are practically alike in showing very large decrease of hardness with increasing section. Chromium-molybdenum steels, corresponding to ECMo 200, and steels with high chromium and manganese contents retained comparatively high core strengths even at large sections. The notch-toughness of nickel-free, high-chromium case-hardening steels with less than 2% Cr depends largely on the tensile strength. The optimum range of tensile strength for ECMo 200 was 210,000 lbs./in.²; EC 100 and its higher-alloy strength counterpart had a fairly constant notch-toughness over a wide range of tensile strength.

To avoid excessive accumulation of carbides in the transition zone (a tendency of steels with higher chromium and molybdenum contents) it is recommended in carburizing to dilute the carburizing compound with already-used compound to prevent over-carburization of the transition zone. Ha (3a)

Locomotive Firebox Steels

"FACTORS INFLUENCING THE SERVICE OF FIREBOX MATERIALS." RAY MCBRIAN (Denver & Rio Grande Western R.R.) *Railway Mech. Engr.*, Vol. 114, Dec. 1940, pp. 531-535. Review and investigation.

The important factors that have not been fully understood or readily recognized in the service life of firebox materials are: (1) effect of temperature, (2) surface strength, and (3) aging properties. The effects of temperature are much better understood now than a few years ago, when specifications were based on room-temperature properties. Several instances of service failures are cited that could be traced to exceeding the elastic limit of the steel at its operating temperature.

If a piece of firebox steel has been "burned," this will be evident in tremendous grain growth and incipient fusion at the grain boundaries. Staybolt irons, too, should be selected for their high-temperature properties, since such service failures as pulled bolts and leaky boxes are attributable in many cases to the use of "standard" staybolt irons with very low tensile properties at 1000° F.—a temperature which is evidently often exceeded at the surface of the structure.

Standard A.A.R. firebox steels are also subject to decarburization at the surface during service, sometimes 0.01 in. being depleted of carbon in this way. It is here (at the surface) that fatigue cracks originate and it is also here that temperatures are highest and the greatest strength required. Steel staybolts are also subject to surface weakness due to decarburization.

Aging—a spontaneous loss of ductility and increase in strength properties with the passage of time—is accelerated in firebox service by the cyclic stresses and elevated temperatures associated with the firing-up cycle. In one series of tests of boiler-washing cycles ranging from 2 days to 30 days, the least aging occurred on sheets in locomotives operating on a 30-day washout schedule. Steels showing a marked susceptibility to peak properties in the "blue-brittle" range (300°-600° F.) are more susceptible to aging than others. Testing methods for measuring the capacity of a steel to age are now under development.

These service problems would be ideally solved by a non-aging uniform material whose strength under all operating conditions would be greater than the maximum stress imposed on it. Firebox steels and staybolt irons containing molybdenum have behaved satisfactorily in service.

Carbon-moly steels provide much higher yield strength and ultimate strength at operating temperatures than do standard firebox materials, and thus restrict excessive deformation and aid in preventing leaks. Also, molybdenum steel plates retain greater surface strength, in the face of decarburization, than do non-alloyed firebox steels, since the molybdenum dissolves in the ferrite and gives it added strength. (3a)

Nitrogen-Bearing Stainless Steels

THE SUBSTITUTION OF NITROGEN FOR NICKEL IN CORROSION-RESISTING AUSTENITIC CHROMIUM-NICKEL ALLOYS ("Zur Frage des Ersatzes von Nickel in korrosionsbeständigen austenitischen Chrom-Nickel-Legierungen durch Stickstoff") W. TOFAUTE & H. SCHOTTKY. *Tech. Mitt. Krupp, Forsch. Ber.*, Vol. 3, July 1940, pp. 103-110. Investigation.

Nitrogen is absorbed by chromium-containing steels in larger amounts than it is by unalloyed steel, and plays the same role in the alloys as does carbon in the

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Condition of Plate	Yield Point	Tensile Strength	% Elongation 2″	R.A.
As Rolled	56,690 p.s.i.	83,000 p.s.i.	40%	
Stressed Relieved (6 hrs. at 1115° F. Furnace cooled)	55,410 p.s.i.	81,650 p.s.i.	44%	
Heat Treated	126,200 p.s.i.	135,150 p.s.i.	22.6%	54%

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—25°F.	50 foot pounds (Charpy Keyhole)

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steel. Therefore, it should be possible to substitute nitrogen for nickel in austenitic chromium-nickel steels. Nitrogen is more soluble in the gamma phase than in the alpha phase and thus increases hardenability, and aids the undercooling of austenite to room temperature.

A chromium steel of 23% Cr and 0.06 C without any other additions was studied. The required nitrogen was added in the form of nitrogen-containing ferrochromium. Virtually entirely-austenitic alloys with less than 0.1% C were obtained. The austenitic structure of such steels with high chromium content was found to be stable both during long-time annealing and cold working.

Composition, %			Heat Treatment	Elastic Limit lbs./in.²	Tens. Strgth. lbs./in.²	Elongation %
Cr	Ni	N				
23	0	0	1650° F., water-quench	51,200	66,200	33.9
23	1	0	1650° F., water-quench	59,000	70,100	23.6
23	1	0.26	1750° F., water-quench	77,500	133,000	19.3
23	4	0.27	2000° F., water-quench	85,300	130,000	44.9

These steels are mechanically characterized by a remarkably high elastic limit and high deformability, and thus combine the advantages of the martensitic-troostitic and the austenitic chromium-nickel steels (the German VM and VA types). They are suitable for deep-drawing and can be readily welded, without subsequent heat treatment. Their corrosion resistance in oxidizing acids and chloride solutions is equal or superior to that of the 18/8 alloys, and no tendency to intergranular corrosion was observed.

Austenitic chromium - nickel - nitrogen steels can be produced by the same processes and with the same equipment as used for conventional stainless steels on a large scale, and give no difficulty in hot-working. The table shows the mechanical properties of nitrogen-free and nitrogen-containing 23% Cr steels with varying nickel content.

Ha (3a)

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3b. Non-Ferrous

Cadmium Plate vs. Zinc Plate in Marine Environments

"Corrosion Resistance of Cadmium and Zinc Electrodeposits Under Marine Conditions." A. Mankowich (U. S. Naval Torpedo Station) *Monthly Rev. Am. Electroplaters' Soc.*, Vol. 27, Nov. 1940, pp. 833-839. Research.

The corrosion resistance of zinc and cadmium electrodeposits, from 0.0001 to 0.001 in. thick, on steel was determined by continuous immersion of the specimens in 3% sodium chloride solution. The loss in weight of the specimens was taken as an indication of their quality.

The zinc specimens quickly became discolored and showed a steady loss in weight over a 233-hr. period. The cadmium specimens maintained their silvery appearance for about 100-200 hrs. They showed a slight loss in weight during the first 160 hrs. and then an increase in weight during the next 70 hrs., which was interpreted as being due to the formation of an oxide coating.

It is concluded that under severe marine exposure, cadmium is more satisfactory than zinc. AB (3b)

Zirconium in Nickel-Silicon Bronze

"Beneficial Effects of Zirconium in Cast Nickel-Silicon Bronzes." F. R. Hensel, E. I. Larsen & A. S. Doty (P. R. Mallory & Co.) *Metals Tech.*, Vol. 7, Dec. 1940, 4 pp. Investigation.

Cast and age-hardened bronzes containing between 1.5 and 3% Ni and 0.4 to 0.75% Si have erratic properties.

Data on a number of heats of such alloys to which 0.25% Zr was added prove that the addition of this element produces a uniformly high tensile strength—average 65,000 lbs./in.² after aging. Hardness reaches a maximum (with 0.25% Zr) of about 90 Rockwell B after 16 hrs. at 850° F. and conductivity about 37% I.A.C.S. after the same treatment.

Microscopic examination indicated that the bronze without zirconium tended to show wide grain boundaries after aging but that with zirconium present the boundaries were fine and free from excessive segregation. It appears that without zirconium, precipitation at the boundaries is apt to produce a brittle material and that zirconium tends to prevent such adverse precipitation. JLG (3b)

Wear Resistant Light Metals

"Determining Hardness and Wear Resistance in Light Alloys." *Light Metals*, Vol. 3, Dec. 1940, pp. 299-305. Discussion.

It is generally recognized that the property of hardness in metals is one that may be correlated with other mechanical prop-

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erties within certain narrow limits. There is, however, a tendency to make rash suppositions regarding tensile strength and fatigue strength, for example, from hardness tests.

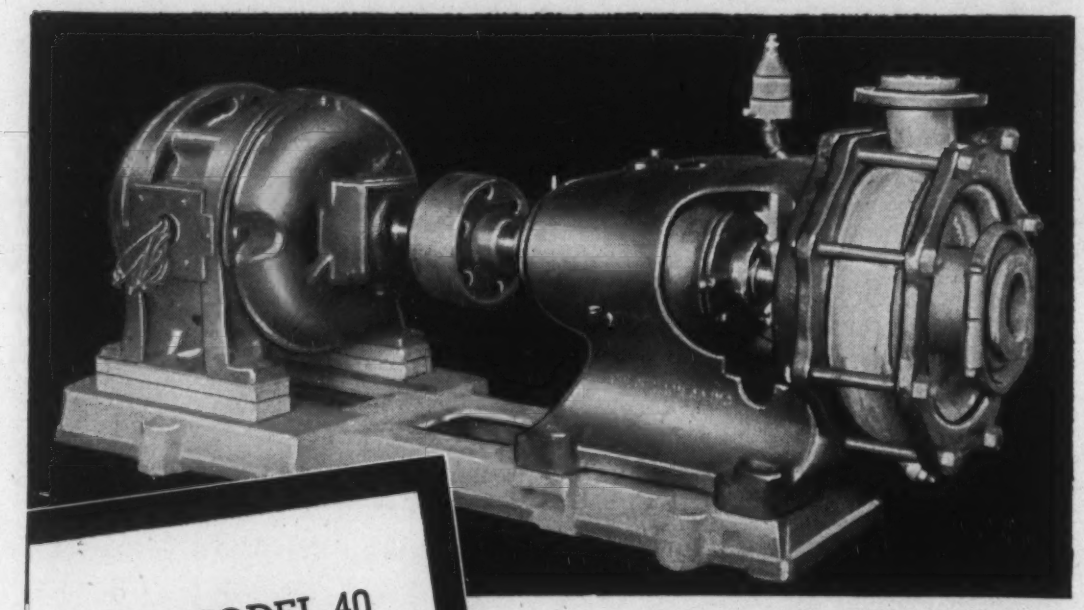
Nevertheless, the hardness test with its simplicity of performance does offer in some cases a convenient method of obtaining a rough indication of certain other properties, based on actual experience with such correlation. For example, in closely related groups of alloys, hardness is often a reliable criterion of the wear resistance, but there is no *general* correlation between hardness and wear resistance.

In a series of tests carried out on the Nieberding wear testing machine, certain patented alloys known as "Zirkonal" and "Quarzal" were shown to be more wear resistant than the high-silicon aluminum alloys, which have been generally recognized as possessing the highest wear resistance of all aluminum alloys. These alloys are very high in copper and contain several other elements. Zirkonal of the following composition had the highest wear resistance: 16.36% Cu, 0.24 Si, 2.95 Mn, 1.03 Co, 1.29 W, 1.67 Cr, 0.55 Na, 0.14 Zn, 0.79 Fe and 2.30 "aging agents." Quarzal is very similar in composition, but does not contain cobalt or tungsten.

The tests were carried out with the use of hand-lapped cast iron discs of various compositions, while the test samples were spherically lapped. The wear was determined under a load of 1 kg. for 10 complete revolutions of the disc. The wear resistance of several other copper-containing aluminum alloys was inferior to that of the silicon alloys. Aluminum alloys containing small quantities of manganese, chromium or tungsten are not appreciably hardened, and smear readily under test; with corresponding low wear resistance.

In aluminum-magnesium alloys, wear resistance increases with increasing magnesium content. "Self-aging" alloys in the cast condition, generally show increased wear resistance with increasing hardness. Aluminum alloys of higher copper content with self-aging constituents added show increasing wear with increasing manganese content.

The wear resistance of magnesium alloys in dry friction against steel is generally between 60-90% that of wrought aluminum alloys. Magnesium alloys appear to be more sensitive to lack of lubrication and rough surfaces than do the aluminum alloys. AUS (3b)



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New Aluminum Bronze

"Some Corrosion-Resistant Wrought Aluminum Bronzes of High Strength." G. Koiso, K. Kusumoto & Masno Yata. *Tetsu-to-Hagane*, Vol. 26, 1940, pp. 537-551; abstracted in *Chem. Abstracts*, Vol. 35, Jan. 20, 1940, p. 422. Research.

The effects of adding nickel, iron, manganese, zinc, cadmium, cobalt, chromium, antimony, titanium and tungsten on the mechanical properties and corrosion-resistance of 2-phase aluminum bronzes were examined.

Nickel in excess of 2% raised the proof stress and hardness, but decreased the ductility, and had an almost negligible effect on corrosion resistance.

A new bronze, called "HB-5", was developed, containing 10.5% Al, 4 Fe, 4 Mn, 1 max. Zn, 0.5 max. Cr, and remainder copper. Its specific gravity is 7.28; thermal expansion coeff. (20°-200° C.) 1.91 x 10^{-5}; electrical conductivity 5.5% of standard copper; and Young's modulus 16,000,000 lbs./in.^{2}

The mechanical properties of complex aluminum bronzes of approximately eutectoid composition vary greatly with minor variations in the aluminum content, rate of cooling, mass of specimen, etc. (3b)

Nickel Alloys for Brewery Use

"The Resistance of Metals to Corrosion by Beer and Ale and Their Effect on Turbidity, Color and Flavor." I. F. Mason, Jr. *Brewers Digest*, Vol. 15, No. 11, 1940, pp. 56-58, 97 (Tech. Sec., pp. 202-204); abstracted in *Chem. Abstracts*, Vol. 35, Jan. 20, 1941, p. 425. Investigation.

To study corrosion losses, disks of metal were mounted, by means of a central hole, on a protected shaft (spool-type holder) and installed in various tanks and portions of brewing equipment.

Corrosion losses varied considerably with the metal used and with its location. Quantitative data are tabulated showing the loss in weight (mg./dm.^{2} exposed surface) after 75 days or less. In general, Inconel showed the least loss in weight, followed by Monel, nickel and copper in approximately that order.

To check the effect of dissolved metals on beer and ale quality, metal chlorides were added to beer and ale in sterilized bottles, which were then stored in darkness. The minimum noticeable metal content, in parts/million, was: for beer—3 Ni, 30 Cr, 1–3 Cu, 1 Sn, 1 Fe; for ale—6 Ni, 30–60 Cr, 6 Cu, 1 Sn, 6 Fe. Chromium and nickel had less effect on color, flavor and turbidity than the other metals. (3b)

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Corrosion Testing

ACID-RESISTANT STEELS — CORROSION-RESISTANCE TESTING ("Säurebeständige Stähle, Gesichtspunkte zur Beurteilung ihrer Beständigkeit") H. J. ROCHA. *Tech. Mitt. Krupp, Forsch. Ber.*, Vol. 3, No. 13, Nov. 1940, pp. 191-198. Research.

In the search for a reliable method for appraising the corrosion-resistance of nickel-poor chromium steels and also of acid-resistant non-ferrous materials, it was found that current density-potential curves are very suitable. These curves are obtained by combining the steel to be investigated as one electrode with a non-polarizable auxiliary electrode into an electrolytic cell on which (after compensating for the natural potential difference between the two electrodes) increasing voltages are impressed, the steel electrode being the anode. The change of potential of the steel electrode with the change of current in the cell is measured.

The curves show three potential ranges: One is at low voltages in which the steels are active; here, hydrogen is evolved from the acid (as with zinc in acid). In an intermediate potential range, the steels are passive and behave like platinum, the potential corresponding to the oxidation potential of the solution. At very high voltages, attack again takes place with direct oxidation (as of copper in oxidizing H_2SO_4).

The 3 ranges are separated from one another by well defined limiting potentials (the activation potential and the breakdown potential), and the actual corrosion behavior of a steel depends on the specific potential range into which the steel is brought by the oxidizing properties of the solution. In the usually non-oxidizing acids such as sulphuric, phosphoric, and many organic acids, even the oxygen dissolved in them from the air is enough to polarize certain steels beyond the passivation potential. Acid-resisting steels are actually used in practice in both the active and passive conditions, as well as "beyond the breakdown."

The action of chromium, nickel, molybdenum and copper is different in the 3 potential ranges as is shown by the "permanence diagrams." The "passivity limit" is identical with the "permanence limit," but sometimes an unstable passivity is produced by a lag in the breakdown, and this offers some protection against overload in operation.

The breakdown-potential is also a limiting factor in neutral and weakly acid chloride-containing solutions; if it is exceeded pitting results. The breakdown potential can, however, be exceeded to a certain degree in nitric acid; in this case, attack sets in uniformly over the whole surface, with formation of visible protective oxide layers. Ha (4)

Equilibrium Diagrams

"DENDRITIC STRUCTURE." C. H. DESCH. *Foundry Trade J.*, Vol. 63, Nov. 28, 1940, p. 351; Dec. 5, 1940, pp. 365-366. Review.

In determining equilibrium diagrams, failure to allow sufficient time for equilibrium to be obtained by diffusion tends to make the gap between the solidus and the liquidus larger than it should be; in eutectiferous systems the eutectic line is extended further to the left than it should be, and in the case of a solid solution the range between the solidus and the liquidus is increased.

On the other hand, when the solidus is determined by heating curves, the effect of lack of equilibrium is to give a bowed form to the solidus. In most of the published iron-carbon diagrams the curve representing the solidus, or bounding the austenite region, has been usually of that shape. In steel solid solutions the austenite crystals reveal composition gradients within the dendrites.

The chief composition gradient is that of phosphorus. High phosphorus concentrations have the effect of expelling carbon, so that carbon segregation also is observed. In alloy steels there is a further significance of this dendritic structure. Not only phosphorus, but also the alloying elements are unevenly distributed across a dendrite. Thus, with different compositions, the different portions of the dendrite have different transformation points and rates,

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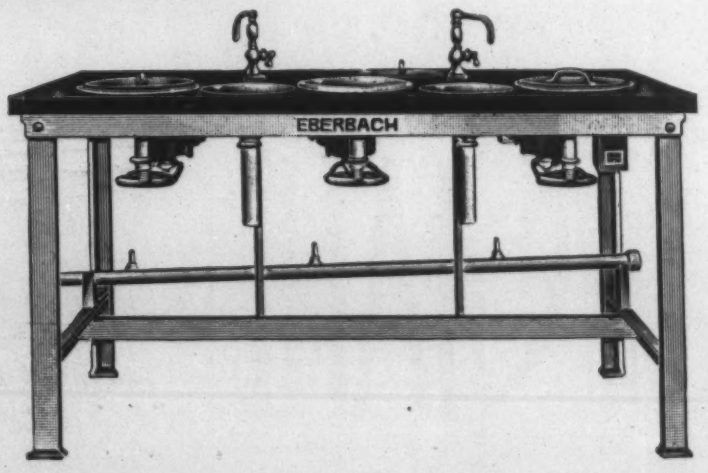

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and internal stresses and cracks may well be the result.

There are 11 methods that might be used to determine the actual composition gradient within the dendrites of certain alloys: chemical etching, contact printing, microchemical examination of shavings, spectrographic study of isolated spots, determination of electrolytic potential at points, measurement of the electrolytic potential as a whole, X-ray microscopy, X-ray transmission pictures, the thermomagnetic method, electrical resistance, and the broadening of X-ray lines. AIK (4)

Radiographic Intensifying Screens

"Radiographs in the Modern Manner." Robert C. Woods (Bell Aircraft Corp.) *Iron Age*, Vol. 146, Dec. 5, 1940, pp. 35-39. Practical.

A lead foil technique that permits decrease in exposure time and also brings out clear cut details, and some properties of the calcium tungstate intensifying screen are discussed.

The greatest disadvantage of the calcium tungstate screen is that it intensifies not only the direct, primary radiation components but also the softer, less penetrating rays scattered from and emitted by the object. In the radiography of irregular shapes it is thus often impossible to use this screen. The chief problems are to decrease the excessive exposure times on dense objects and yet bring out clear details.

The advent of lead foil intensifying screens has made this possible. The use of lead foil screens is based on partial filtration of the scattered and secondary radiation and photographic image intensification by electron emission. Two sheets of 0.005 in. lead foil fastened on semi-rigid backings can be mounted on cassettes and handled the same as calcium tungstate screens. Electron impact will expose grains of photographic emulsions, as do photons of light or X-ray intensification.

The mechanics of the phenomenon is similar to that of the calcium tungstate screen, except that photoelectrons discharged from the lead surface next to the film are substituted for fluorescent light rays. Each electron is very small compared to the calcium tungstate crystal and so does not expose large numbers of emulsion grains. The drawback is that 2 lead screens produce intensification of only 2:1 over no-screen practice, as compared to 100:1 or more for calcium tungstate.

Even so, the increased radiographic quality obtained with lead screens offsets other necessary increases in voltages and exposure time. VSP (4)

High Temperature Fatigue Tests

Fatigue Properties of Threaded Specimens at Various Temperatures, and the Effect of Surface Working ("Die Dauerhaltbarkeit von Gewinden bei verschiedenen Temperaturen und ihre Beeinflussung durch Oberflächendrücken") W. Bertram. *Mitt. Wöhler Institute*, No. 37, 1940, pp. 3-52.

Data have been lacking on notched or threaded fatigue tests at elevated temperature. This work only partly fills this gap. He studied 3 steels as follows:—a 0.44% C steel of 90,000 lbs./in.^{2} room-temperature tensile strength; a 0.26% C, 1.29 Cr, 1.23 Mo steel of 118,500 lbs./in.^{2} tensile; and a 0.22% C, 0.99 Cr, 0.90 Mo, 0.05 V steel of 118,500 lbs./in.^{2} tensile. No details are given as to any heat treatment that may have been used.

The torsional endurance tests used were non-standard, in that instead of running several specimens to fracture and plotting the S-N curve, a single specimen was first run for 2 million cycles at some load selected to be below the endurance limit, then the load increased 10% and the test continued. If the bar did not break in the second 2 million, the load was increased another 10%, and so on.

The endurance limit is then guessed at by interpolation, according to a method peculiar to the Wöhler Institute and not endorsed by most other investigators of fatigue, since steels differ in response to understressing so much the method is basically unsound.

Bertram's claim of proper temperature control and proper temperature uniformity over the gage length of his specimens is not substantiated by enough evidence to justify complete faith in the accuracy of his temperature figures. For these reasons the data must be taken as merely tentative, though moderately comparable among themselves.

Smooth, polished, unnotched specimens of the plain carbon steel and of the chromium-molybdenum steel were tested in reversed torsion, using specimens 0.47 in. diam. with a 1.57 in. gage length. The alloy steels were also tested as 1⅜ in. threaded specimens. The threaded specimens were cold worked at the root of the thread by pressing a hardened roller that fitted the thread into them till the root diameter of the threaded portion was decreased by 0.008 in. Smooth specimens of the carbon steel and of the chromium-molybdenum were similarly cold worked by 3 rollers in the manner commonly used at the Wöhler Institute.

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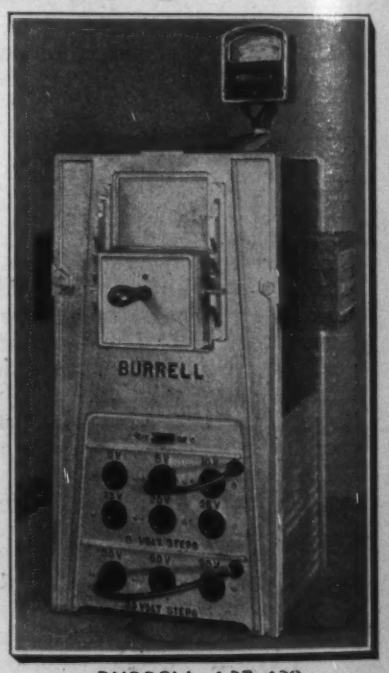

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The torsional endurance limit given by Bertram is merely an interpolation of doubtful validity, but his figures do indicate that it is unsafe to make predictions about endurance at elevated temperatures without actual tests, as well as that the beneficial effect of cold working is retained, in some steels, to quite elevated temperatures, but is not particularly effective.

When his data are plotted, a decided hump is shown in the curve at 750° F. for smooth specimens of the chromium-molybdenum steel, worked or un-worked. This test temperature was omitted in the tests on threaded specimens of the alloy steels, the plots for which, due to skipping this temperature, are relatively smooth curves. With this case in mind, other smooth curves in the literature resulting from plotting a paucity of data should be regarded with suspicion.

One observation in the course of this work deserves mention. A steel of 0.15% C, 0.38 Mn, 0.42 Si, 0.021 S, 0.028 P, 1.04 Cr, 0.85 Ni, 0.77 Mo at 117,000 tensile, tested as a 1⅜ in. threaded specimen, with the roots of the threads cold-worked, was evaluated by interpolation as having a torsional endurance range of 40,000 lbs./in.², but when tested at a range of around 30,000 lbs./in.², "cocoa" (of the type produced by fretting corrosion) appeared in the thread roots.

Bertram's explanation is that the cold working produced fine cracks, the face of which rubbed together under repeated stress, tearing off fine particles of steel which oxidized to form the "cocoa." He believes that the effective cold working extended deeper than the cracks, so that the improvement in interpolated endurance from 24,000 unworked to 40,000 worked, occurs in spite of the surface cracks.

If a type of surface working is used that inevitably produces cracks, the rate of crack propagation through the substratum of cold-worked material becomes important, so it cannot be assumed that a degree of surface cold working that is helpful to one steel will be helpful to another.

HWG (4)

Evaluating Cracking-Tube Steels

"Evaluation of Steels for Cracking Tube Service by Stress-Rupture Tests." C. L. Clark & W. G. Hildorf. *Refiner & Natural Gasoline Mfr.*, Vol. 19, Dec. 1940, pp. 456-464; abstracted in *Library Bulletin of Abstracts*, Universal Oil Products Co., Dec. 25, 1940, p. 205. Investigation.

In cracking service the metal tube temperatures will vary from 1100° F. at the start of the operating cycle, assuming an oil temperature of 950° F., to 1350°-1400° F. if the coke is deposited on the inner wall as the run progresses. Most deformation or fractures take place during the latter part of the operating cycle. Stress-rupture tests are a convenient means of evaluating steels for this service; it is the authors' intention that they should supplement rather than replace creep tests, however.

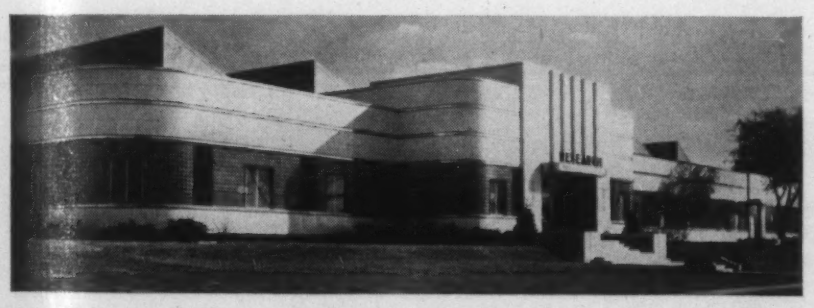
In stress-rupture tests, specimens of each steel at each temperature are broken under constant stress with a series of stresses so selected that failure will result over time periods from a few minutes up to a maximum of several hundred or several thousand hours. Deformation curves can be obtained that are believed to show rates comparable with those obtained during actual bulging or fracture of steel tubes under overstressed conditions.

When stresses and corresponding fracture times are plotted on Cartesian coordinates, the resulting curves are asymptotic to definite limiting stresses, indicating the point below which fracture will not occur for very long time periods. If logarithmic coordinates are used, there is a straight-line relation over the entire time period if the steel has adequate surface and structural stability; if either is lacking, there is a break in the straight line after a certain time.

Stresses required for various fracture times can be determined from these curves and extrapolation is permissible. A plot of stress valves against temperatures is useful in indicating the behavior of a given steel under overheating and overstressing conditions.

Stress-rupture tests were applied over the range 900°-1500° F. to 20 steels of 4 types representing a wide range of corrosion resistance and surface stability: (1) silicon below 0.50%, (2) silicon above 0.50%, (3) aluminum-bearing steels, and (4) austenitic steels. Strength did not increase continuously with increasing chromium content, and was usually improved by an increase in molybdenum content from 0.5 to 1.0%. Strength at high temperatures was raised by higher silicon contents, owing to the greater surface stability of the resulting steels.

For service under oxidizing conditions more severe than those in the test, or in the presence of corrosive media, the higher alloy steels are necessary. The relation



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Experimental heats of iron and steel are melted down in small Ajax-Northrup High Frequency Furnaces with current supplied by a 35 KVA Ajax-Northrup Converter.

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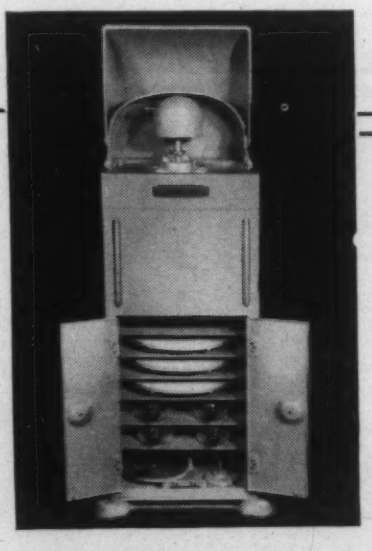

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THE PROPERTIES OF LEAD

Tensile Strength and Elongation

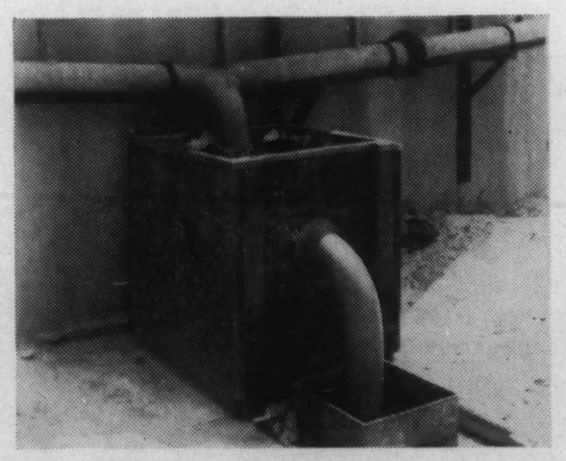
Lead is not considered a strong metal and consequently is rarely used structurally by itself. Nevertheless the tensile strength of lead is a material factor in its fabrication and many of its uses. The commercial grades of lead vary in strength depending on the nature and amount of the impurities present. For example, laboratory rolled specimens tested at room temperature with a pulling speed of ¼" per minute per inch of test section, show the following variations:

GRADE OF LEAD	TENSILE STRENGTH P.S.I.	ELONGATION %
Common (99.85+ .13 Bi)	1931	34.4
Corroding (99.99+ .006 Bi)	1904	37.7
Common (99.98+ no Bi)	2093	43.0
Chemical (99.92+ .06 Cu)	2961	42.2

The alloying of small amounts of certain elements with lead, can materially strengthen the metal.

In rolled commercial sheet:	TENSILE STRENGTH P.S.I.	ELONGATION %
Chemical Lead	2454	57.0
Chemical Lead—.062 Tellurium	3229	41.0
In extruded tape:		
Chemical Lead	2200	48.0
Chemical Lead—.038 Calcium	4047	36.0
Chemical Lead—.05 Calcium	4903	31.0
Laboratory rolled specimens:		
Chemical Lead	2900	43.0
Chemical Lead—.5 Antimony	3216	57.5
Chemical Lead—.5 Antimony—.25 Cadmium	3400	56.5

Depending on service conditions the thickness and unsupported span in lead pipe installation are determined, in part, by the tensile strength of the metal. At right is a settling tank, showing lead pipe entering and leaving the tank.



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between rupture strength and creep strength appears to vary with composition of the steel, but is generally independent of temperature; that between rupture strength and tensile strength varies with both temperature and composition.

At 1000° F. under the test conditions both plain carbon and 0.50% Mo steel lose ductility rapidly at longer fracture times. At 1300° F. 18-8 stainless also loses ductility rapidly, with an elongation value of 11% after 7200 hrs. The good degree of ductility shown by 4-6 Cr-Mo at 1000° F. decreased rather rapidly 300° F. higher. Plain carbon steel retained its ductility better at 1300° than at 1000° F.

Metallographic examination of the specimens is of value in showing the type of failure, and throwing light on the effects of time, temperature and stress on surface stability.

When the stress-rupture characteristics of a given steel have once been completely established, the load-carrying ability of other steels of the same type may be established by fracturing at least 3 specimens at time periods of 2, 15 and 250 hrs. to determine the slope and position of the logarithmic lines; if the lines lie above the previous one it is logical to assume that the strength has been increased.

Repetition of certain of the more prolonged tests would insure that the stability over longer times had not been influenced by changes in composition. The stress-rupture tests thus may serve as an acceptability test in indicating whether a given heat of steel has the desired load-carrying ability. (4)

X-ray Structure and Elastic Strain

"X-ray Structure and Elastic Strains in Copper." S. L. Smith & W. A. Wood. *Proc. Roy. Soc.* [*A*], Vol. 176, Nov. 1940, pp. 398-411. Original research.

The changes in X-ray structure occuring when a flat specimen of vacuum-annealed very pure copper was tested in tension were observed.

Below the "yield point," which occurred at 45,000-56,000 lbs./in.^{2}, elastic strain was accompanied only by a change in dimensions of the lattice. There was no permanent distortion of the lattice, and the changes were reversible. In the X-ray photographs, the rings were observed to expand or contract without any change in the degree of their diffusion.

Above the "yield-point," when permanent set was produced, the grains suffered an irreversible break-up into crystallites. It was noted that, in the polycrystalline metal, a given applied external strain produced very different amounts of strain in neighboring grains. JCC (4)

Defects in Heavy Wall Pipe

"Surface Defects in Heavy Wall Pipe." Sabin Crocker (Detroit Edison Co.) *Heating, Piping & Air Conditioning*, Vol. 13, Jan. 1941, pp. 12-15. Discussion.

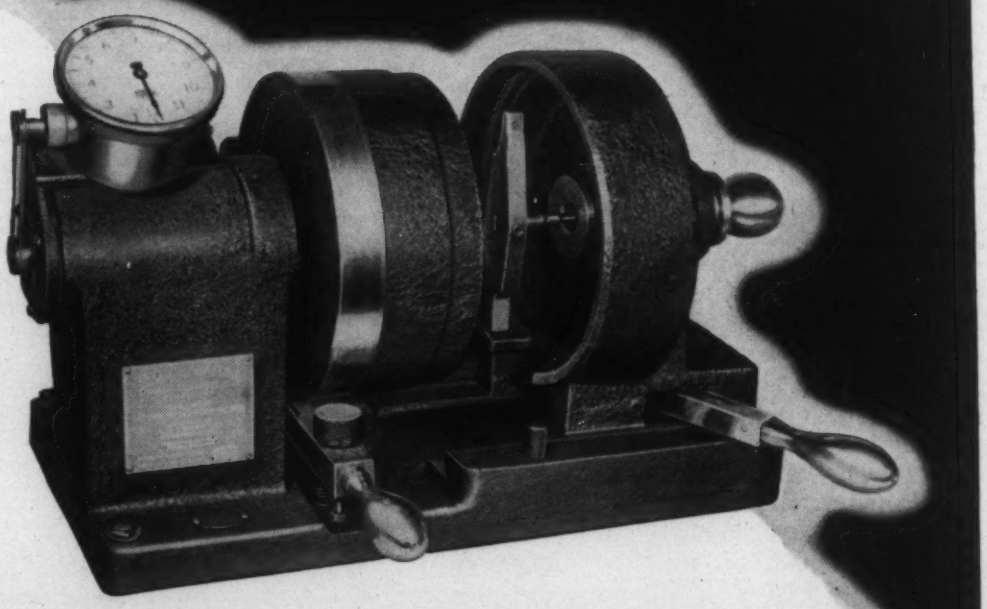
Difficulties in obtaining carbon-molybdenum steel pipe with satisfactory surface finish have led to incorporating specific requirements in A.S.T.M. specification A 206-40T and in specifications A 106-40 and A 158-40T, in place of references to "workmanlike finish," "moderate" and "immoderate" slivers, etc. In the absence of definite standards for surface defects (scabs, pits, seams, laps, tears, cracks, cable marks, dinges, guide marks, scores, fish scale, etc.) each consumer has to be an authority unto himself, and different purchasing standards permit a producer's successfully selling material rejected by one customer to another.

Subcommittee 22 of A.S.T.M. committee A-1 delegated to a subgroup the establishing of tentative standards for surface condition of pipe. The proposed specifications are characterized by their specific wording. All defects shall be explored for depth. U-bottom marks and abrasions shall be acceptable "as is" if no deeper than 12% of the nominal wall thickness. V-bottom marks no deeper than 12% of the wall thickness, however, must be machined out.

Fish scale less than 1/64 in. deep need not be removed; between 1/64 in. and 1/32 in. deep such defects shall be removed by machining; fish scale deeper than 1/32 in. shall be cause for rejection. Scabs, seams, laps, tears or slivers over 5% of the wall thickness must be removed by machining. Finished pipe shall be rejected if any of these surface defects, even though acceptable by virtue of individual size, are not scattered but appear over a large area in excess of what is considered workmanlike finish.

One fabricator objects to the provision that U-bottom mechanical marks of limited depth be acceptable, pointing out that such defects may be objectionable because of their number even though their depth is within "acceptable" limits. He also believes that any *seam*, regardless of depth, should be eliminated by filing or grinding out. (4)

FOR IMPACT TESTING
OF HARD STEELS AND BRITTLE MATERIALS



Far more sensitive than Izod, Charpy or tension tests, the torsion impact method is the only practical form of impact test for hard steel or brittle materials. It is particularly adapted to studying the effects of internal strains and variations in grain structure and gives a usable measurement for the control of heat treatment.

The Carpenter Torsion Impact Machine does not use a notched bar and therefore notched brittleness is not a factor. Tests are readily reproducible. A few machines are now available from stock, subject to prior sale. Write for Bulletin S-154

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books

Ancient and Modern Metals

THE SONS OF VULCAN. *By Thomas Hibben. Published by J. B. Lippincott Co., Philadelphia, 1940. Cloth, 6¼x8¼ in., 259 pages. Price $2.00.*

After a discussion of primitive tools and ancient methods of working and mining metals, the author describes the discovery and early uses of metals and alloys, particularly copper, bronze, iron and steel. The development of the locomotive as an example of the use of iron is discussed at length, and whole chapters are devoted to the blacksmith's shop and the armorer's craft. The book ends with an inscription from an Egyptian temple, which the reader will echo, "Oh, Artisan, thou art the perfect man."

There are numerous illustrations, taken from various sources but all redrawn by the author in a simple pleasing style. Those who are familiar with the original woodcuts or engravings will regret that they were redrawn, for the flavor of the old illustrations and an occasional important detail have been lost without commensurate gain in clarity or uniformity.

This is by no means a technical history of the metallurgical arts; indeed the metal expert and historian both will find a fair number of errors. The delightful manner of telling the tale, however, makes up for its inaccuracies and the book will serve admirably to interest older children and the non-technical laity in metals. Metallurgists and metallurgical engineers would do well to put a copy on the shelves of their local school library.

—CYRIL S. SMITH.

Welding Metallurgy

WELDING METALLURGY. *By O. H. Henry & G. E. Claussen. Published by American Welding Society, New York, 1940. Cloth, 5¼x8 in., 359 pages. Price $1.50.*

This is a fascinating book. Everyone who wishes to be posted on the metallurgical factors that underlie the art of fusion welding will find much of value in it. The authors have discovered a lot of things to write about and metallurgical engineers will do well to look here for guidance in this application of their science.

On the other side of the ledger may be placed a mediocre printing job and some slips in metallurgical theory. To cite a few cases to indicate what is meant, the pipe cavity of a steel ingot is shown open at the top; discussions of "red shortness" are misleading and inaccurate; and no distinction is made between brittleness and brittle behavior. Also an index would help.

However, these do not detract seriously from the main objectives of the book, which are to classify the important metallurgical effects, to show their practical significance in a quantitative manner, and to help the welder improve his art through a better understanding of all that goes on in its practice.

—S. L. HOYT.

Ingot Brass and Bronze

INGOT BRASS AND BRONZE. *Published by Non-Ferrous Ingot Metal Inst., Chicago, 1940. Looseleaf-ring binder, 8½x11 in., 73 pages. Price $5.00.*

Fourteen bronzes and red or yellow brasses, 3 grades of manganese bronze, 2 of aluminum bronze, and 4 "nickel silvers," all obtainable as secondary ingot, are listed each with its own data sheet, giving ranges of composition (with permissible impurities), of mechanical and physical properties, references to the various official specifications covering such material and brief listing of uses for which it is suitable. Other sections deal with the utility of ingot metal, nomenclature, foundry practice and foundry defects. Gating, molding and core sands, and pouring temperatures are among the topics discussed.

The manual is handy. Its lists of specifications are especially convenient. The publishers plan to issue supplemental material from time to time that can be directly inserted in the manual.

—H. W. GILLETT

Magnetic Inspection

PRINCIPLES OF MAGNAFLUX INSPECTION. *By L. B. Doane. Published by Magnaflux Corp., Chicago, 1940. Cloth, 6 x 9 in., 133 pages. Price $2.50.*

The magnetic powder method of inspection of magnetic materials for cracks and analogous defects has become a highly important tool, so widely used that this book, which one is tempted to call a relatively non-technical discussion of a very special technique, is timely. The tricks that may be employed to facilitate inspection and increase the reliability of the indications are clearly set forth.

The necessity for experience and judgment in accepting or rejecting on the basis of the magnetic powder test is frankly stated, and the limitations of the test are not minimized nor its possibilities too glowingly stated.

To anyone having to use this test method or to evaluate its results, the book is indispensable.—H. W. GILLETT.

Other New Books

CHAMBERS'S TECHNICAL DICTIONARY. *By C. F. Tweney and L. E. C. Hughes. Published by The Macmillan Co., New York, 1940. Cloth, 5¾ x 8¼ in., 957 pages. Price $5.00.* A useful volume giving definitions of technical terms used in engineering and science, including much of the nomenclature of metallurgical engineering.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS. VOL. 140. IRON AND STEEL DIV. *Published by American Institute of Mining & Metallurgical Engineers, New York, 1940. Cloth, 6¼ x 9¼ in., 514 pages. Price $5.00.* Contains 23 papers (and their discussions) on the metallurgy of iron and steel, plus Herty's Howe lecture on slag control.

BIBLIOGRAPHY OF SPECTROCHEMICAL ANALYSIS. 2ND EDITION. *By D. M. Smith. Published by British Non-Ferrous Metals Research Assoc, London, 1940. Paper, 6 x 10 in., 55 pages. Price 3S.* The first edition of this bibliography appeared in 1935 (see METALS AND ALLOYS, Vol. 7, Oct. 1936, p. 504 L 5) and contained references to papers published since the Associations' Research Monograph No. 2 on metallurgical spectrography was issued in 1933 (see METALS AND ALLOYS, Vol. 5, Apr. 1934, p. MA 15). The new edition contains 510 references, with very brief abstracts, to papers published since 1933 up to Aug. 1940.

ARC WELDING INSTRUCTION COURSE—LECTURES. *Published by Air Reduction, New York, 1940. Cloth, 8½ x 11 in., 89 pages. Price $1.00.*—EXERCISES, *101 pages. Price $1.00.* The "why" and "how" of arc welding with bare or coated electrodes, for beginners.

INSTRUCTIONS IN OXYACETYLENE WELDING AND CUTTING PROCESSES—LECTURES. *Published by Air Reduction, New York, 1940. Cloth, 8½ x 11 in., 94 pages. Price $1.00.*—WORK SHEETS, *31 pages, Price $0.50.* Manuals for learners in the arts of acetylene welding, machine gas cutting, flame descaling, flame hardening, etc.

PROCEEDINGS OF THE FOURTH ANNUAL FORUM, PORCELAIN ENAMEL INSTITUTE. *Published by Porcelain Enamel Inst., Chicago, 1940. Paper, 4 x 9 in., 183 pp. Price $2.00.* Contains all the papers presented to the October 1939 meetings at Ohio State Univ., including some on causes of defects, cast iron bases, cleaning and pickling, drawing compounds, and annealing between draws.

SIMPLE BLUEPRINT READING. *Published by Lincoln Electric Co., Cleveland, Ohio, 1940. Simulated leather, 6 x 9 in., 138 pages. Price 50c.* A valuable little book for the metal fabricator. Especial emphasis is placed on welding and welding symbols.

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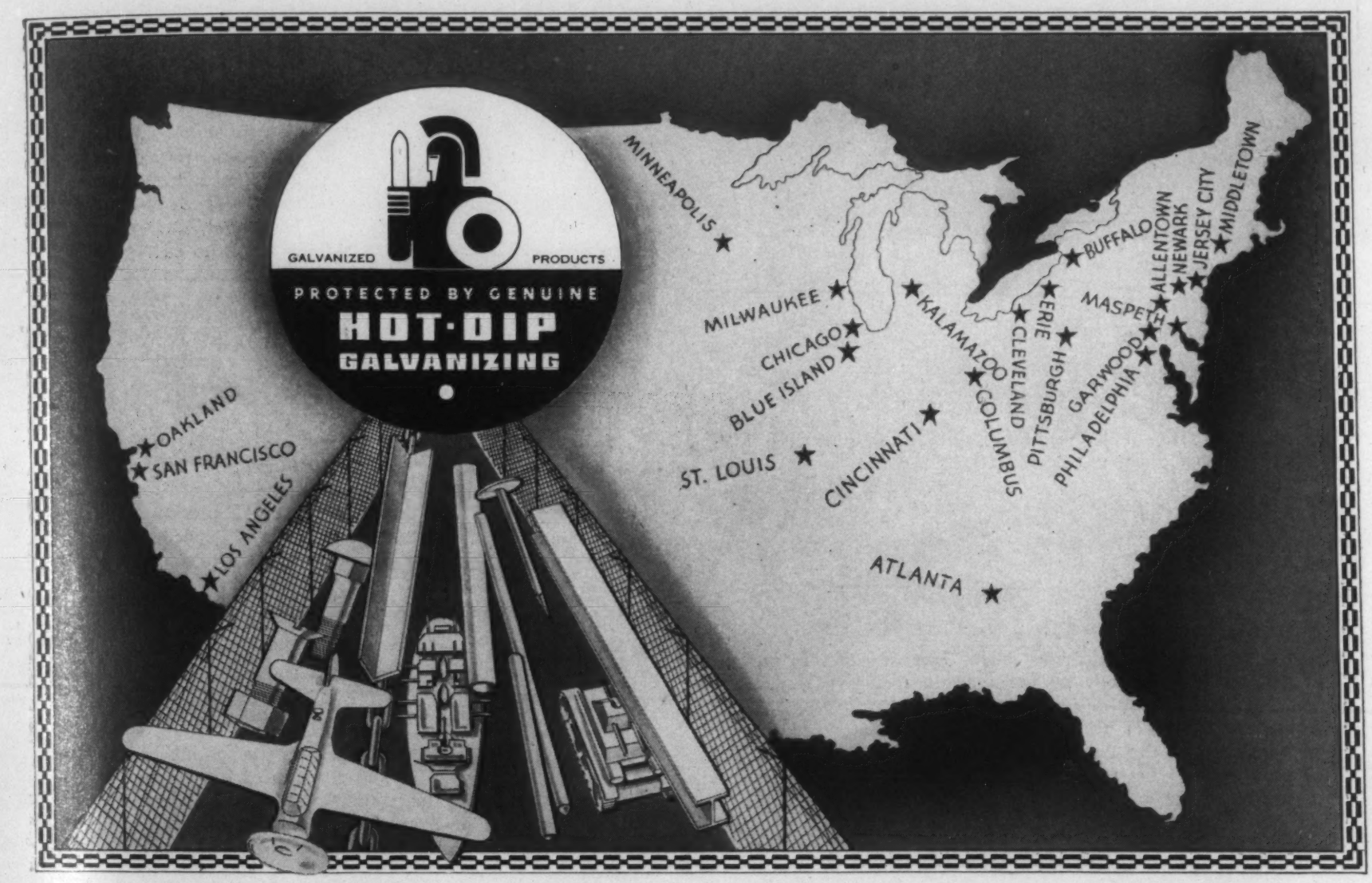

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trends

By Edwin F. Cone, Editor

Larger Welding Operations

"In the larger welding operations, economy of operation obtained by positioning the work and using high current downhand electrodes with attendant higher rates of metal deposition has emphasized the trend to more high capacity welding units, 400 amp. direct current and 500 amp. alternating current units."—W. W. Reddie, Westinghouse Elec. & Mfg. Co.

Nickel in Automotive Industry

Last year was the first one in which the total amount of nickel used in trucks and busses exceeded that in passenger cars—due partly to the increase in heavy duty units which use higher alloy percentages and partly to a greater amount of nickel alloy steel used per truck, according to a statement by the International Nickel Co., Inc. About 23 per cent of the total amount of nickel produced is consumed by the automotive industry.

Sodium

The world production of sodium exceeds 300,000 tons a year, said Dr. Colin G. Fink in a recent address. Next to iron, it is the cheapest of all metals on a unit volume basis. It is one of the eight most common metals in the earth's crust and large quantities are consumed each year in the organic chemical industry. Tetraethyl lead is one important product made with sodium. A new application of the metal is the new sodium arc lamp for lighting highways.

Steel Wages

The trend in steel wages has been upward. In 1940 they were the highest in the history of the industry and were among the highest paid by any manufacturing industry in the country, according to a study by the American Iron and Steel Institute. Since May, 1940, steel workers have earned an average of 85½ cents per hr. or nearly 2 per cent more than the previous peak of 84.2c per hr. during 1939 and 30 per cent above the average of 65.4c paid in 1929.

Research in Aluminum

During 1940, research has been responsible for important developments of brazing aluminum alloy products, in increasing application of anodic treatment finishing processes for aluminum, improving the merits of aluminum house paint, and continuing to open up fields for the use of aluminum in marine applications—according to a statement of the Aluminum Co. of America.

Nickel for Italy

Italy's need of nickel is so urgent that nickel coins have already been withdrawn from circulation so as to result in the recovery of about 1600 metric tons of the metal, says the American Consulate General at Milan, as published in *Foreign Commerce Weekly* for Nov. 9. The coins are being replaced with those made of "acmonital," an Italian alloy of steel and nickel. The withdrawal from circulation of remaining nickel coins will result, it is said, in the recovery of another 2,900 tons of nickel.

Steel Output in 1940

More than 66,500,000 net tons of steel ingots were produced in the United States in 1940 according to a statement by the president of the American Iron and Steel Institute. This is fully 8 per cent above the previous high of 61,400,000 tons in 1929 and about 27 per cent in excess of the 1939 production of 52,500,000 tons. According to present indications, the 1941 output will exceed all previous totals.

Cold Strip Rolling Speeds

The trend in cold strip rolling has been for higher rolling speeds. Recently a rolling speed of 2,100 f.p.m. was considered an upper limit but in 1940 a tandem mill with a top speed of 2,500 f.p.m. was put in service and a mill with a maximum delivery speed of 3,850 f.p.m. was ordered.

Hot Strip Mills

One of the trends in hot strip mills has been an increase in width and in rolling speed. Two pioneer hot strip mills, built in 1926 and 1928 respectively, were increased last year in width and their rolling speed radically raised so as to be more in line with lately built modern mills.

Iron Ore

The output of iron ore in the United States in 1940 is estimated at 73,806,000 gross tons, an increase of 43 per cent over that mined in 1939. Except for 1916 and 1917, last year's production was the largest on record. These data do not include ore containing 5 per cent or more of manganese.

(Other "Trends" on page 376)

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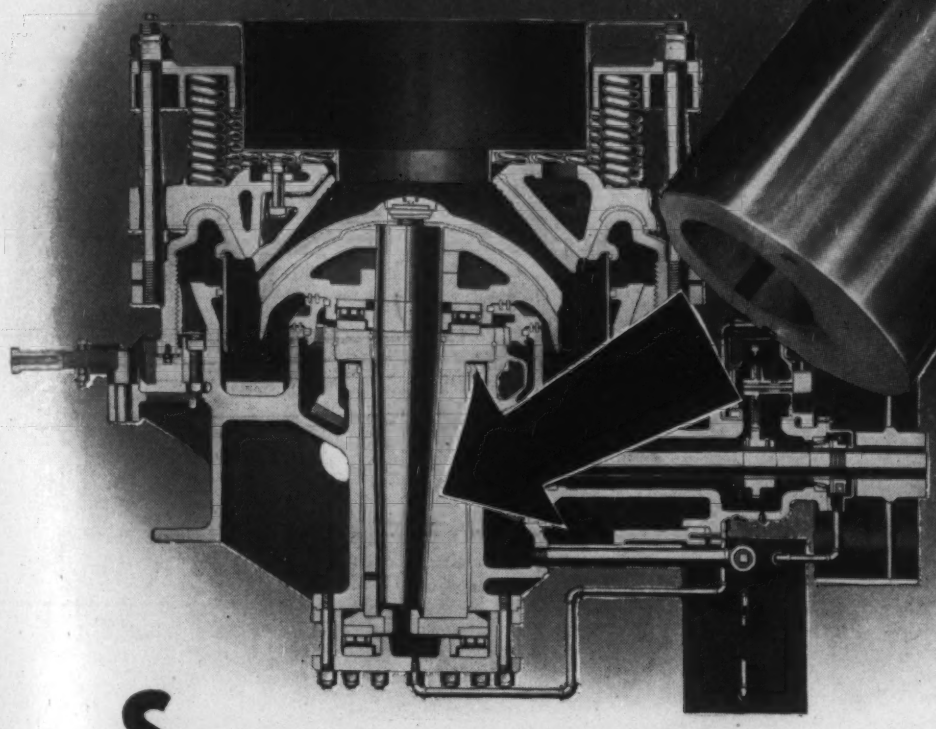
√ FAILURE
√ POOR BEARING SURFACE



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Charleston, W. Va.	Kanawha Manufacturing Co.
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Chicago, Ill.	Greenlee Foundry Company
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Cincinnati, Ohio	The Cincinnati Milling Machine Co.
Cleveland, Ohio	Fulton Foundry & Machine Co.
Denver, Colo.	The Stearns-Roger Mfg. Co.
Detroit, Mich.	Atlas Foundry Co.
Flint, Mich.	General Foundry & Mfg. Company
Hamilton, Ohio	Hamilton Foundry & Machine Co.
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Pittsburgh, Pa.	Rosedale Foundry & Machine Co.
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trends

By Edwin F. Cone, Editor

Zinc Alloy Die Castings

More zinc alloy die castings were produced in 1940 than in any previous year, states the annual report of the American Zinc Institute, Inc., New York. "This was due in large measure to a greater appreciation of the physical and economic aspects of this metal and method of parts production. Metallurgists and engineers who, just a few short years ago were feeling their way with these die castings, are now specifying them for applications in which full advantage is taken of their functional possibilities."

Zinc

It is indicated that in Germany and Great Britain zinc is already being used to some extent as a substitute metal. * * * * Zinc used in brass in 1939 totaled 175,000 tons. Data for 1940, when available, will no doubt exceed the record of 185,000 tons in 1929. * * * * The sheet division, the largest in the galvanizing field, consumed 275,000 tons of zinc in 1939. Figures for 1940, when issued will probably be not far from the record of 291,000 tons in 1928.—Facts gleaned from the annual report of the American Zinc Institute.

Copper

Total mine production of recoverable copper in the United States (Alaska included) in 1940 at about 873,377 net tons showed an increase of 20 per cent over 1939. It was one of the largest in the history of the United States and was exceeded only in the war years of 1916, 1917 and 1918 and the boom years of 1928 and 1929.

Cadmium

New peaks in the production and consumption of cadmium were reached in 1940, according to the U. S. Bureau of Mines. Output of metallic cadmium at 6,101,000 lbs. in 1940, was 38 per cent over the 5,190,273 lbs. in 1939. In 1938 the production was only 2,525,666 lbs. Apparent consumption of the metal is roughly estimated at 6,900,000 lbs. or about 28 per cent over that of 1939. Price for the entire year was practically 80c per lb.

Steel Ingot Capacity

The capacity of the American steel industry for making steel ingots reached a new high as of Dec. 31. The total is 84,152,000 net tons according to the American Iron and Steel Institute—an increase of more than 2,500,000 tons for the year and 15 per cent higher than the 72,985,000 tons on Dec. 31, 1929. An interesting fact is that in these estimates generous allowances are made for time lost by periodic necessary shutdowns. If necessary the industry could produce 86,250,000 tons, working at full capacity. The increase last year is due not only to new furnaces, but to modernization and enlargement of old ones.

Electric Steel

Four 50-ton electric steel melting furnaces were added in 1940 by the Republic Steel Corp., increasing its annual electric steel capacity from 159,000 tons 5 yrs. ago to 388,000 tons. Two more 50-ton furnaces now being installed will add 112,000, making the company's capacity 500,000 net tons per year.

Cobalt

Before the present war, most of our supply of refined cobalt came from Belgium; it was refined there from African ores. Canadian production has lately increased; it was 907 tons in 1938 but about 2,700 tons in 1940, according to Dr. Zay Jeffries. Arrangements are now being made to ship African concentrates to the United States for refining here.

Platinum-Clad Products

Industrial use of platinum as a corrosion-resistant material is expanding, largely because of the availability of platinum-clad sheet, tubing and rod. Because of the larger output of platinum as a by-product from the treatment of the nickel ores of Canada by the International Nickel Co. the metal is becoming cheaper.

More Electric Furnaces

A builder of American electric steel melting furnaces makes the significant statement in an advertisement that his company sold 71 electric furnaces in 1940—emphasizing the recent trend in this field.

Aluminum

Production of primary aluminum in 1940 in the United States at 412,560,000 lbs. exceeded the peak reached in 1939 by 26 per cent. The 1939 output was 327,090,000 lbs. The consumption of the metal last year is estimated at 35 per cent over that of 1939, according to the U. S. Bureau of Mines. Expansions in capacity are expected to insure an output of over 700,000,000 lbs. before the end of 1942.

(Additional "Trends" on page 374)